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YESTERDAY

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WATER POLLUTION CONTROL FEDERATION 1928

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PROCEEDINGS
37th ANNUAL CONVENTION
WINNIPEG '85

SEPTEMBER 18th — 20th
WESTIN HOTEL

WESTERN CANADA WATER AND SEWAGE CONFERENCE

PROCEEDINGS

of the

37TH ANNUAL CONVENTION

including the

15TH ANNUAL CONVENTION

of the

WESTERN CANADA SECTION
AMERICAN WATER WORKS ASSOCIATION

and the

13TH ANNUAL CONVENTION

of the

WESTERN CANADA POLLUTION CONTROL ASSOCIATION
WATER POLLUTION CONTROL FEDERATION

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PROBLEMS ASSOCIATED WITH WATER TREATMENT IN COLD CLIMATES

by

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INTRODUCTION

Water is indispensable to life; water is the possible carrier of disease organisms; water, as it comes from a tap, is considered to be perfectly safe for human consumption; water is the worlds largest volume manufactured product; water, a product being prepared for human consumption receives less interest, attention and research than does wastewater, a product which is being readied for disposal.

In the Northern portion of the United States and Canada the treatment of water is complicated because these areas enjoy winter conditions from 6 to 9 months a year and cold water does not act in a manner similar to warm water.

The United States engineering oriented literature, that is the Journals of AWWA and ASCE, contains very little information on water treatment at low temperatures. The Journal of the Canadian Society of Civil Engineering - the publication of the Canadian Society for Civil Engineering, has had no papers on water during its 11 years of publication.

In Western Canada the population density is low and many small towns and villages are centres of concentration in the south; there are very few such centres in the north. There are very few continually flowing rivers in the south while about one-half of the north is water covered. In the south, except for a few communities drawing water from the Saskatchewan River System, most centres using surface water employ reservoirs which hold water from one spring run-off until the next. This reservoir water deteriorates in quality during the winter and may become undesirable due to an increase in the Total Dissolved Solids, Sulfate, Hardness, and Hydrogen Sulfide content, and becomes difficult to treat.

Much of the water stored in reservoirs is of the Sodium Sulfate type reflecting the geochemistry of the prairie soils. The analyses of Blackstrap reservoir in Table I may be taken as being typical of this type of water. Much worse water than this is used for human consumption, an example being Dellwood Reservoir water.

The Water in the South Saskatchewan system is taken to be of the Calcium Bicarbonate type. This water, the analyses of which is shown in Table I is twice as mineralized as the average river water in North America but according to prairie standards is considered to be of excellent quality.

TABLE I

CHEMICAL ANALYSES OF WESTERN WATERS

	Dellwood Reservoir	Blackstrap Reservoir	S. Sask. River	Churchill River	Reindeer Lake
pH	7.8	8.2	8.3		
TDS	1560	517	269	120	30
Ca	281	121	120	53	11
Mg	363	120	40	16	4
Na	216	64	24	4	1
K	26	7.5	2.3	1	0.7
Fe	0.3	<0.05	<0.05	<0.08	<0.005
Mn	0.7	<0.01	<0.01	<0.01	<0.05
HCO_3^-	289	132	142	54	13
SO_4	721	231	66	3	1
CL	50	12	2	2	<1
NO_3	0.2	1.8	0.9	0.005	0.003
F	0.2	0.1	0.14	-	-

NOTE: 1) all values given in mg/l except pH
2) Calcium, Magnesium and Alkalinity given as $CaCO_3$; all others as ions.

Water from the Northern part of the Provinces reflects that the drainage areas change from soil to precambrian granite as they progress northward. The mineralization of the water is often very low and streams with a total dissolved solids content of less than 50 mg/l are not unusual. This water changes little with the season and its quality may be considered "too good to treat". Table I shows the analyses of some of the water encountered in the Province of Saskatchewan.

Most surface water treatment plants in Saskatchewan were constructed in the 1950's and 1960's and were often of the "Standard Plan" variety. The usual treatment facilities provided were for alum coagulation, sedimentation, granular media filtration, and chlorination, either solution or gas. Little flexibility existed in the plants and usually no provision was made for different treatment methods which might have been required in the future. There is little indication any study was undertaken on the waters to be used.

It was the exceptional case where a municipality had sufficient funds to correctly size, must less overbuild, their water treatment plant. The plants therefore were sized to meet the minimum demands of 20 to 30 years ago, set by a small population which was not accustomed to "water on tap". The plants operated as reasonably as could be expected during the warmer water summer season, and because of the lowered demand they continued to operate reasonably well in the cold water winter season.

With an increasing demand for water by an increasing population a number of the plants are no longer producing an adequate output. Problems are arising with

all the treatment unit operations and processes. Coagulation, filtration, disinfection, taste and odor control, and softening are all sources of problems during the winter cold water temperature period.

Recognizing the extent of these problems a study is being carried out in the Sanitary Engineering Laboratories at the University of Saskatchewan to identify and remedy cold temperature water treatment problems. This report must be considered preliminary in nature and encompasses only a small portion of the problems which are planned to be investigated.

LABORATORY STUDIES

The studies reported herein deal with jar test and filtration treatment conducted in parallel at room temperature and low temperature on South Saskatchewan River water, Blackstrap Reservoir water and Dellwood Reservoir water.

The Sanitary Engineering Laboratories at the University of Saskatchewan are equipped with three Bally Refrigeration walk-in temperature and humidity controlled chambers, 2.7 m x 5.5 m x 3.0 m (9 ft. wide by 18 ft. long by 10 feet high). Each is capable of maintaining the equipment and stored water temperature just above freezing.

The treatment studies were carried out at temperatures representative of summer conditions (room temperature) and of winter conditions (cold room temperature).

The treatment techniques investigated were the use of Aluminum Sulfate (Alum), Ferric Chloride (Iron) and Calcium hydroxide (Lime).

The City of Saskatoon water treatment plant subjects the raw water to split treatment lime softening in order to maintain control of the filtration process as the raw water is nearly devoid of turbidity during much of the year. The economics of lime softening are such that a two mile, 1420 mm (56 inch) diameter raw water inlet pipe was installed to a fossil fueled electrical power generating station. This line conveys the heated condenser cooling water to the water treatment plant where it acts as the raw plant influent. This condenser water is normally about 10^{o} C (18^{o} F) above the temperatures of the river water. This system of warm water input is economically sound and the capital, operating, and hot water purchase costs are recoverable from savings in chemical costs.

The addition of lime to form a dense floc has been suggested at other plants when the usual practice of alum flocculation failed during winter when there was no turbidity in the water and the temperature was very low.

The concept is actually one of softening the water to a point where the Magnesium is precipitated as Magnesium Hydroxide floc. Often this solution to poor coagulation is not attainable due to deterioration of other parameters.

In this report this treatment with lime is referred to as softening and the treatment with alum and iron is referred to as coagulation.

The ultimate object of the study was to produce a filtered water which contained a turbidity of one Jackson Turbidity Unit or less and a Color of one True Color Unit or less. These criteria exceed the Canadian Drinking Water Guidelines but are considered attainable in laboratory experiments.

COAGULATION - Results and Discussion

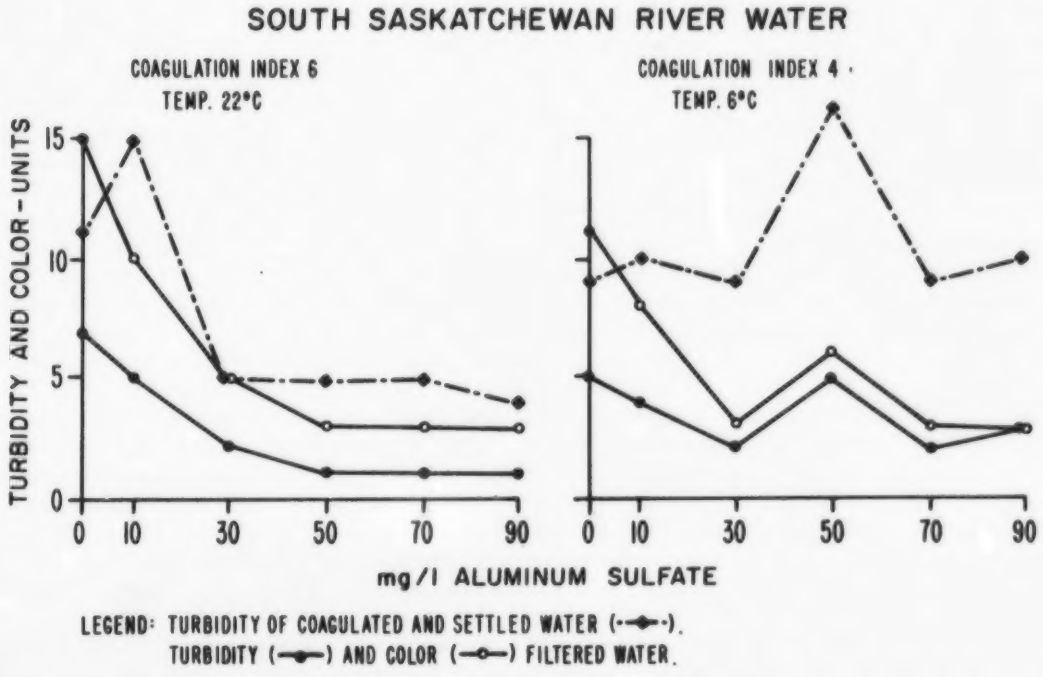
A method was required to quantify the coagulation characteristics of the various waters, so they could be compared one with another. The jar test procedure used in the laboratory calls for a number of judgements to be made by the technician on such observations as: Time of floc appearance; size of floc; 50 percent settling time, percent of stragglers, etc. These subjective inputs were combined with quantitative results to obtain a Coagulation Index based on a 1 to 10 scale from poor to superior.

In the coagulation portion of the study it was determined that the addition of more than 90 mg/l of alum and of iron to the South Saskatchewan River water and Blackstrap reservoir water did not result in any improvement in treatment and in some cases resulted in a great reduction. Dellwood Reservoir Water required considerably more chemicals to reach the best treatment levels.

The results obtained in the coagulation portion of the study for the three waters are shown in Figures 1 to 6. The treatment of South Saskatchewan River water (see Figure 1) at summer temperatures with alum did not produce water of the required quality as the color colloid was not effectively removed even though the turbidity was. A Coagulation Index of 6 was recorded.

FIGURE 1

The Effect of Coagulant Dosage on the Turbidity of Settled Water and the Turbidity and Color of Filtered Water



Alum coagulation of the same water at winter temperatures did not produce an acceptable effluent based on either the color or turbidity criterion. A Coagulation Index of 4 was recorded.

The use of iron coagulant with the water at both summer and winter temperatures produced an excellent product meeting the objective criteria with the addition of 70 mg/l of coagulant. This is shown in Figure 2. Very little difference was experienced in summer and winter temperature operation but the technician recorded a Coagulation Index of 9 to the summer operation and an 8 to the winter operation. It is apparent that alum is the coagulant of choice for the South Saskatchewan River water during summer and Iron is a better coagulant during winter.

FIGURE 2

The Effect of Coagulant Dosage on the Turbidity of Settled Water and the Turbidity and Color of Filtered Water

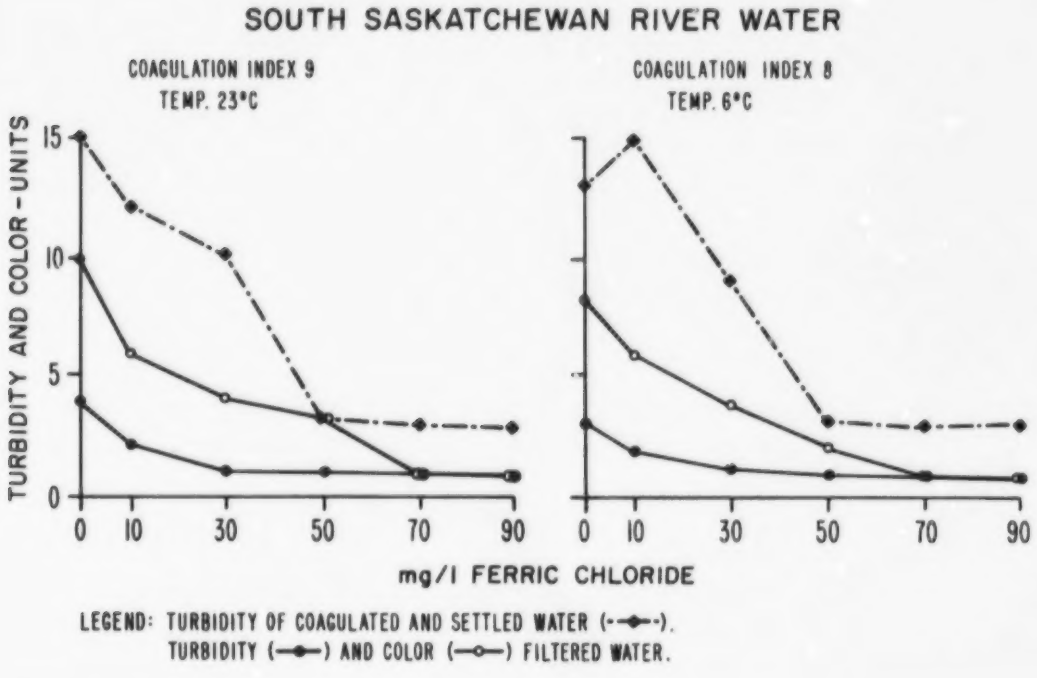
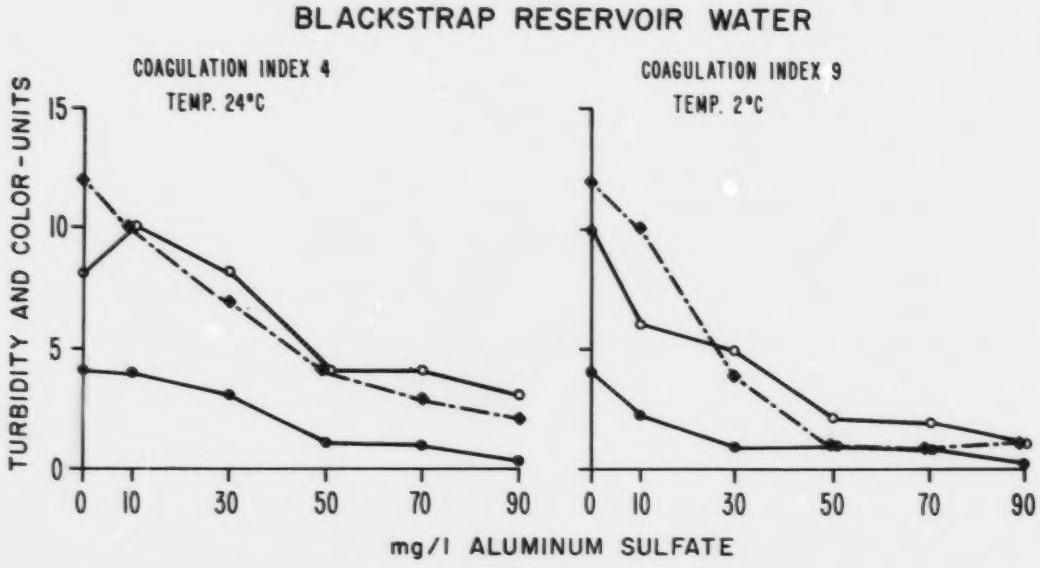


Figure 3 shows the results of the addition of alum to Blackstrap Reservoir water. At summer temperatures the treatment never produced an effluent which met the criteria from the Color removal point of view even at 90 mg/l feed rate. At winter temperatures alum provided better treatment reaching at 50 mg/l the level of 90 mg/l did at summer temperatures; at 90 mg/l the water met the criteria for both color and turbidity.

Figure 4 shows the results of treatment of Blackstrap Reservoir water with iron. At summer temperature a very difficult settling floc formed which could remove the turbidity to the required level at 70 mg/l feed rate, but had no effect on the color colloid. The water was very difficult to filter and a Coagulation Index of 1 was recorded.

FIGURE 3

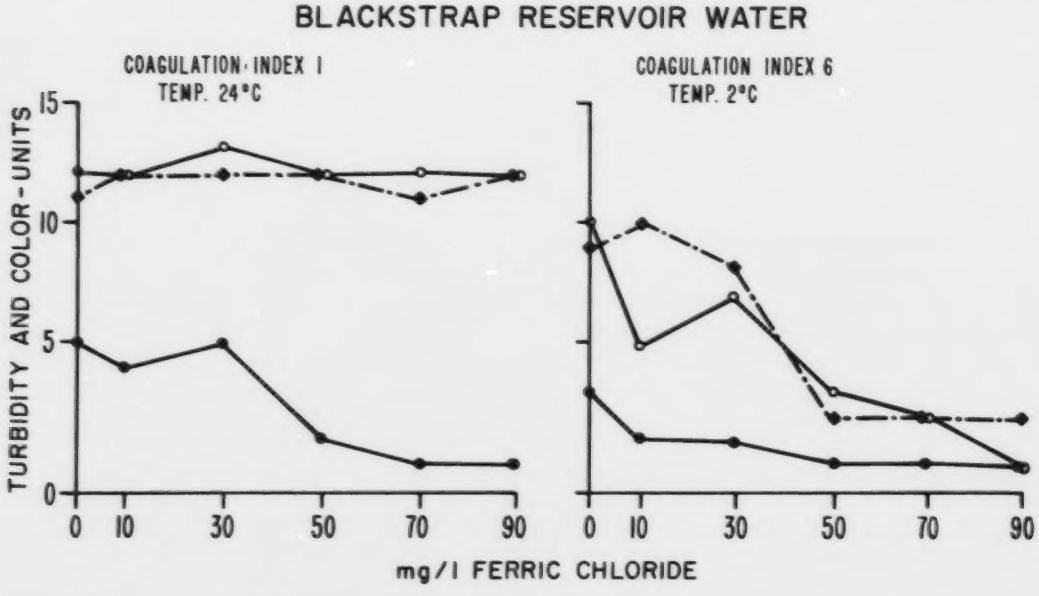
The Effect on Coagulant Dosage on the Turbidity of Settled Water and the Turbidity and Color of Filtered Water



LEGEND: TURBIDITY OF COAGULATED AND SETTLED WATER (-●-).
TURBIDITY (—●—) AND COLOR (—○—) FILTERED WATER.

FIGURE 4

The Effect of Coagulant Dosage on the Turbidity of Settled Water and the Turbidity and Color of Filtered Water



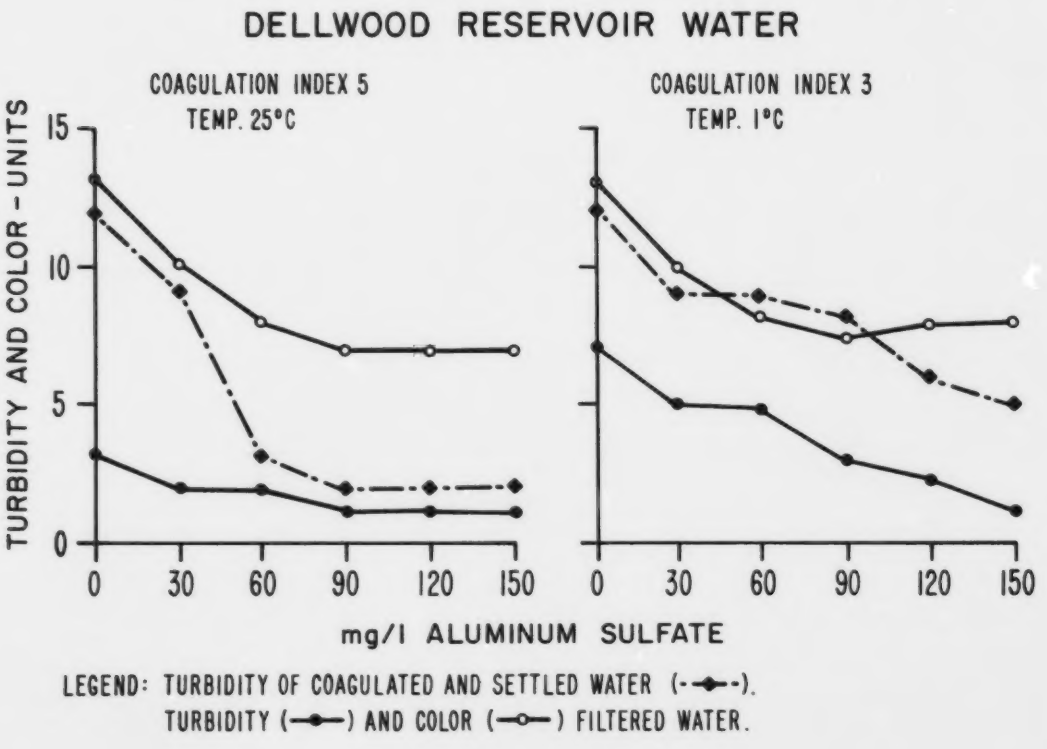
LEGEND: TURBIDITY OF COAGULATED AND SETTLED WATER (-●-).
TURBIDITY (—●—) AND COLOR (—○—) FILTERED WATER.

On the other hand, iron treatment at winter temperatures created a dense fast settling floc which when settled and filtered produced a water which met the effluent criteria, albeit at a dosage of 90 mg/l. A Coagulation Index of 6 was recorded for this water.

Figure 5 records the results of treatments of Delwood Reservoir Water with alum. At summer temperature the color colloid of the filtered water was not substantially reduced reaching a plateau of 7 color units at 90 mg/l. The turbidity however, met the criterion upon the addition of 90 mg/l of the coagulant.

FIGURE 5

The Effect of Coagulant Dosage on the Turbidity of Settled Water and the Turbidity and Color of Filtered Water

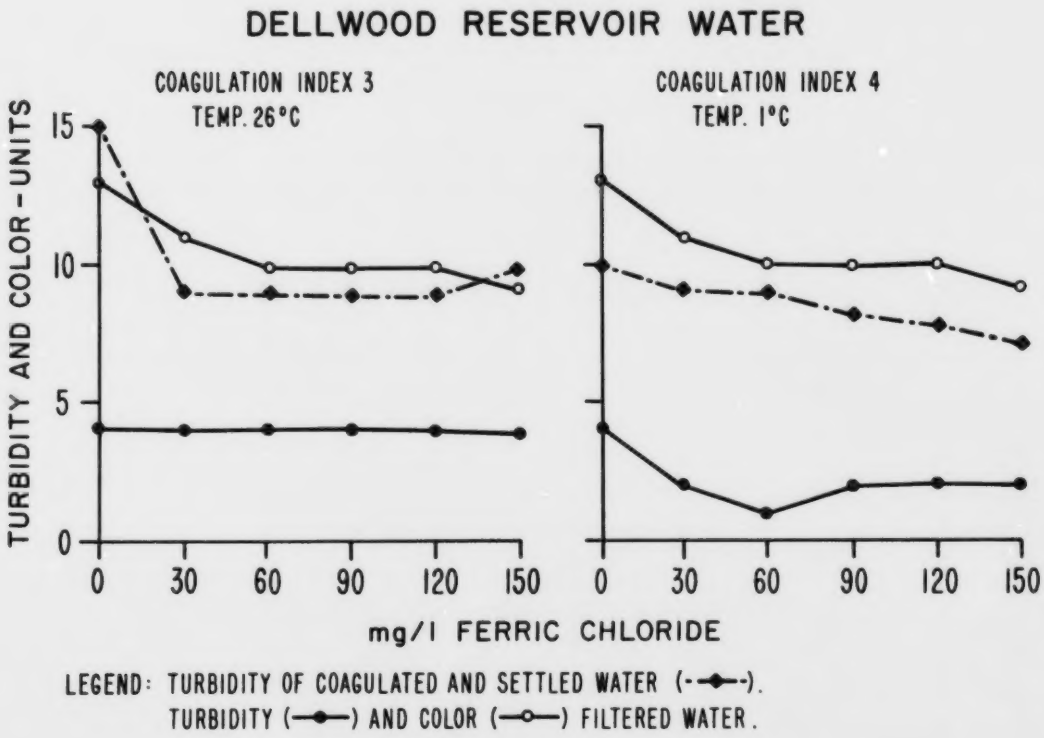


At winter temperatures the color reached a plateau of 8 color units at 90 mg/l feed rate, but the filtered water turbidity did not reach the criterion until the feed was increased to 150 mg/l of coagulant.

Figure 6 shows the results of treating the Dellwood Reservoir Water with iron coagulant. As with the Blackstrap Reservoir water iron coagulant formed a very fine, poor settling floc which at summer temperature removed very little color and no turbidity. At winter temperatures there was no improvement in color removal; however, the filtered turbidity removal did increase but was not consistant at the criterion level.

FIGURE 6

The Effect of Coagulant Dosage on the Turbidity of Settled Water and the Turbidity and Color of Filtered Water



SOFTENING

The results of lime addition to the water under study are shown in Figures 7 to 9. Figure 7 depicts the case of the South Saskatchewan River water. The optimum dosage for both minimum filtered water color and turbidity and maximum softening at summer temperatures was 60 mg/l of Lime. Above this figure the color and turbidity increased and there was no improvement in the total and calcium hardness reduction.

At winter temperature the optimum feed rate for color, turbidity, and total and calcium hardness removal was also 60 mg/l of lime. At a dosage above this all parameters increased. Attention is drawn to the values of total and calcium hardness resulting from the addition of 20 mg/l lime addition. They are both higher than the original values.

At both summer and winter temperatures the settled water turbidity increased especially at the cold temperature. The small sized precipitate could be filtered with good results but did place a heavy load on the filter.

FIGURE 7

The Effect of Lime Dosage on the Turbidity of Settled Water and the Turbidity of Color, Total and Calcium Hardness of Filtered Water

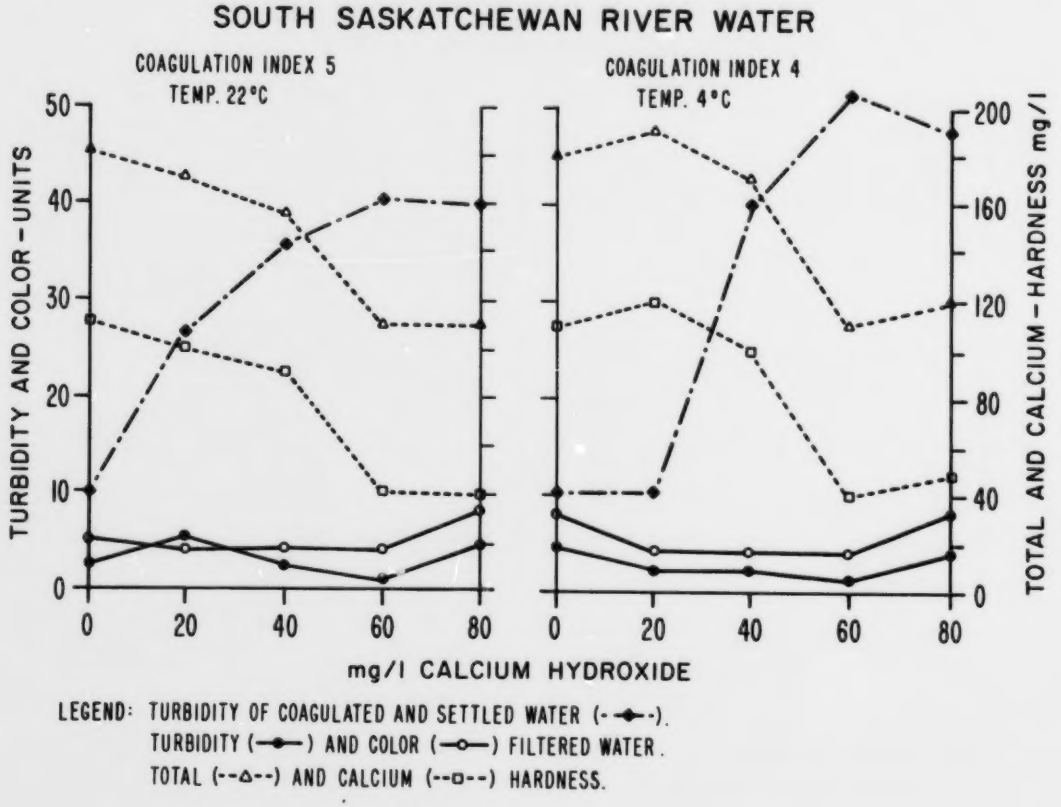

SOUTH SASKATCHEWAN RIVER WATER
COAGULATION INDEX 5
TEMP. 22°C
COAGULATION INDEX 4
TEMP. 4°C
TURBIDITY AND COLOR - UNITS
TOTAL AND CALCIUM - HARDNESS mg/l
mg/l CALCIUM HYDROXIDE
LEGEND: TURBIDITY OF COAGULATED AND SETTLED WATER (-◆-).
TURBIDITY (—●—) AND COLOR (—○—) FILTERED WATER.
TOTAL (--△--) AND CALCIUM (--□--) HARDNESS.

Figure 8 shows the results of the addition of Lime to Blackstrap Reservoir water. At summer temperatures the filtered water color and turbidity increased with increasing lime dosage as a result of the increase in the settled water turbidity - there was also an increase in the total and calcium hardness at 20 mg/l lime feed rate. The treatment produced an exceptionally poor water which was awarded a Coagulation Index of 1.

At winter temperatures the treated water was even worse. The turbidity of the settled water increased to 224 units resulting in massive break through of turbidity and color in the filtered water. The total and calcium hardness increased for doses up to 40 mg/l before returning to about their original levels.

FIGURE 8

The Effect of Lime Dosage on the Turbidity of Settled Water and the Turbidity, Color, Total and Calcium Hardness of Filtered Water

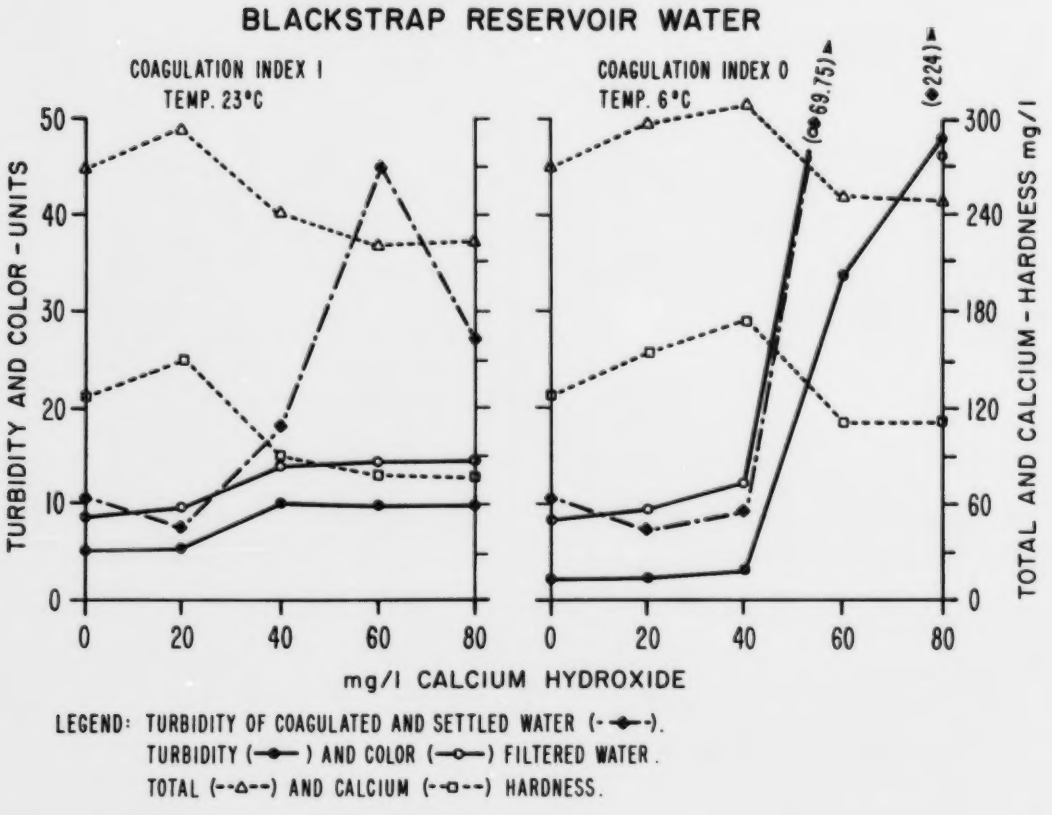
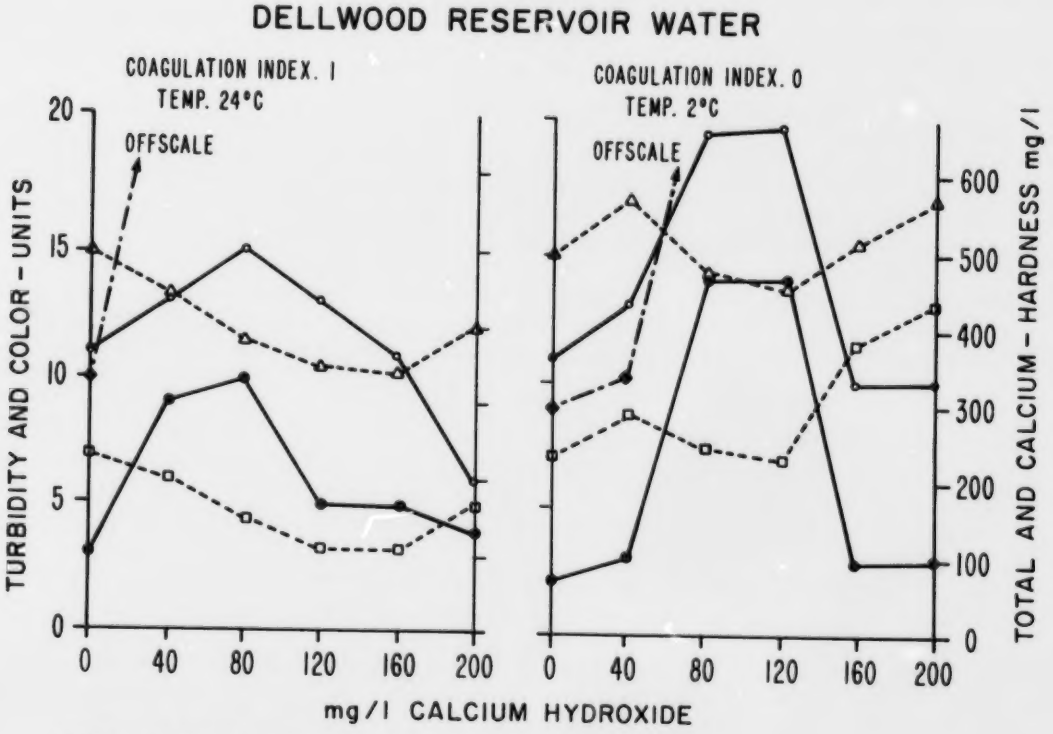


Figure 9 depicts the results of the application of lime to Dellwood Reservoir water. An extremely fine precipitate was formed and the turbidity of the settled water went off scale in both the summer and winter temperature tests. In the case of the summer test the treated water did filter fairly well but at 200 mg/l lime there was a 50% reduction in color but a 30% increase in turbidity. The total and calcium hardness reached a minimum at 120 mg/l of lime and increased 50 mg/l when the dose was increased to 200 mg/l. At winter temperatures the settled turbidity went off scale, there was no removal in filtered water color or turbidity. The total and calcium hardness after an initial increase at a dose of 40 mg/l fell to about the original level at 120 mg/l and then increased steadily with increasing lime doseages.

FIGURE 9

The Effect of Lime Dosage on the Turbidity of Settled Water and the Turbidity, Color, Total and Calcium Hardness of Filtered Water



CONCLUSIONS

1. Every water is different and must be understood to be different.

2. The broad brush approach to treatment must be set aside in favor of a specific investigation of a particular water.

3. The suggested treatment train must be carried out on the specific water in question.

4. If a specific water changes quality during a year optimum treatment for all conditions needs to be investigated.

5. If a specific water changes temperature during a year optimum treatment for the whole range needs to be investigated.

ACKNOWLEDGEMENTS

This report records the findings of preliminary investigations of water treatment under cold conditions ongoing at the Sanitary Engineering Laboratories at the University of Saskatchewan and funded in part by the National Science and Engineering Research Council.

Thanks are due to Miss Joni Kimball for laboratory support and Mrs. H. Larson for document preparation.

INFRASTRUCTURE UPGRADING - TRIP/CANADA

by

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The author has been a participant in conventions of this body for some twenty five years, and most of them have been as a bystander who could lament the lack of what the contractors call practical papers dealing with the immediate problems of our industry in the face of many technical presentations which drove the majority of us to the golf course during the presentations of same.

Today the convention has come full circle, because the contracting and engineering side of the industry have developed a position on one of our most pressing problems, and its affects directly on every attendee of this conference.

Simply put, the infrastructure of this country on which, we as contractors, suppliers and engineers derive our various livelihoods in either physically installing product, selling the product itself, or being responsible for the design of such systems is in a state of disrepair across the country.

When I say infrastructure I refer to our road system, bridges, and sewer and water systems and treatment facilities across Canada.

We, as contractors, began to feel the impact of lessening dollars directed to infrastructure concerns some ten years ago, and the first signs of that impact were in the highway budgets of provincial governments.

Since the late sixties our share of the tax pie in real dollars has dropped from approximately 16% of provincial government spending to lows of 7% in our last recorded year 1983.

I don't need to tell you what that has done to contractors across Canada, but it has also had a devastating effect on equipment suppliers and engineering firms across the country, and in fact, the entire economy.

The reduction of expenditures has also had disasterous results in the condition of our principal highway network which range from 80% deficiency in Newfoundland to 25% right here in Manitoba.

And the problem is getting worse, not better.

We formed Trip/Canada, the road information program, in 1983, with a view to developing reports on each province and its principal highway systems to alert the public to the need of reinvestment in our sector of the industry and to show good economic reason for doing so.

We took, as our mandate, the study of all infrastructure, including city and municipal systems and set about the task of gathering information from administrators and going public with the results of our surveys and questionnaires.

The program, public awareness, has been an unqualified success, and the media has been most supportive in carrying our views on the need to direct tax dollars to the most important part of our country's assets, its infrastructure.

The program now beginning its third year has received the support of firstly its author, the construction community, then its suppliers, consulting engineers at both provincial and national levels, and its equipment dealers across the country.

Having completed our initial studies on principal highways we are now turning our attention to the needs of our cities.

Infrastructure, a word seldom heard or understood several years ago has become a conversation piece, not only at a political level but at a public concern level as well.

Some of our cities are beginning to look like bomb shelters as long neglected major rehabilitation work is underway, but we must continue our series of studies and releases to ensure what we see as an address to the problems, remains a dedication by the politician to address the growing public concern.

We must not allow our cities to reach the state of some of our neighbors to the south where the problem of infrastructure neglect has made the cost of repair almost unsurmountable.

We operate as a special committee of the Canadian Construction Association, but our funding, at a cost of some $200,000.00 per year comes directly from those who would benefit from increased activity in the construction community.

When one considers that studies of the Federation of Canadian Municipalities have identified an existing 12 Billion Dollar need across Canada in repairing our cities, the need for survival of our industry to address that problem is apparent.

We have held Press Conferences across Canada, zeroing in on the needs of specific cities to ensure that the local taxpayer, knows why he/she should be supportive of the effort which is beginning across Canada.

Perhaps as suppliers to the industry many of your firms will wish to contribute to the costs of our program which help would be greatly appreciated. Perhaps some of you are now, certainly the engineering community continues to be of assistance, but to this point in time, very few firms supplying product to our contractor in the field of service material have been heard from.

Since our City of Winnipeg release, we have been asked to serve on an adhoc committee of the City of Winnipeg to examine its commitment to infrastructure reinvestment. That's a first for us and our local chapter is awaiting a date to begin those meetings.

Similar reports are being prepared for release on cities such as Vancouver, Edmonton and Calgary, Regina and Saskatoon, Toronto, Halifax and other major cities.

I hope other invitations to help plan the needed address to this subject will be forthcoming.

Our mandate is simple -- to promote the reinvestment of public funding (tax dollars) into the upkeep, repair and protection of those assets we call infrastructure.

To identify the problems facing administrators relating to that care and upkeep to the public in language they can understand and relate to.

Yes! We have a vested interest!

But that vested interest is small when one compares the economic benefits conferred on the nation by putting our people back to work.

We have stressed three basic principals in every public utterance. We do not advocate make work projects. There are enough of them now which serve only to requalify people for unemployment insurance.

Whatever's done must meet the following criteria:

1. It must be necessary.
2. It must be of long term benefit to the taxpayer.
3. It must also save future dollars, dollars whose diminishing future value will simply not be enough to stop the decay we find in our systems.

Companies that have no work contribute nothing to the tax base, employees on unemployment insurance contribute nothing to the system, they only help to drain it.

Where will the money come from to pay for the needs we identify? That answer is not our mandate, but we have said we would support the politician prepared to address the problem. The mix that is needed is the public's perception of a need and the political will to address it.

We talk about the tremendous costs of our social safety nets, and sometimes the media implies that we are promoting our industry by advocating an end to them.

We haven't said to stop financing libraries, recreation facilities or needed health care.

We also like to read, walk in the park, and enjoy good health facilities.

Perhaps a simple hold on increasing those appropriations each year would create at least some of the dollars needed to begin the repair of our cities and municipalities.

We quote recognizable and accepted authorities. It takes the risk out of our making the comments directly but allows us to support them.

Example -- C.D. Howe Institute, a non partisan organization which does not mince words and tackles the real truth, had this to say about social problems including our principal tax burden -- unemployment insurance.

Social Spending: - Expected to reach $50 Billion in 1985. The adequacy and effectiveness of the social safety net could be enhanced at a lower cost if net benefits were related to the incomes of recipients. Spending could also be reduced if programs were redesigned to reduce disincentives to work and the

"welfare dependency" that often results. Unemployment insurance and other income maintenance programs provide benefits that nearly match what some recipients could earn from work. In my industry unemployment insurance equates to paying our people $7.00 per hour to sit at home.

Family Allowance: - An alternative would be to eliminate both the child tax exemption and the refundable child tax credit and replace them with increased family allowance payments that would be subject to an escalating tax-back of benefits as income levels of recipients increases.

That was before the budget came down.

Who else says the infrastructure of the nation is important? Again a recognizable and authoritative opinion. Not a roadbuilder.

On November 11, 1984 the Catholic Bishops of the United States promulgated the draft of a pastoral letter. Catholic Social Teaching and the U.S. Economy.

Their comments as a highlight from that letter: On Full Employment: - Reduce unemployment to 3 to 4% by increasing public service jobs, particularly the repair of roads, bridges and other decaying parts of the nation's infrastructure.

That's a view from the pulpit!

Who else has an opinion?

Page 332 and 333 from a current book on the best-seller list, Iaccoca an Autobiography. The book IACCOCA outlines six points for a new industrial policy in the U.S.A.

Mr. Iaccoca, a car salesman turned chairman of the board, who turned Chrysler around, who labour and business think might make a good president, says as his sixth point for a U.S.A. industrial policy:

"Finally, we need to establish a long-term program for rebuilding America's arteries of commerce - our roadways, bridges, railroads, and water systems. Our infrastructure, which is vital to any strengthening and expansion of our industrial power, is deteriorating at an alarming rate. Something must be done."

Where do our facts come from? Government officials concerned about the problem.

Comparisons - Who is worst? Not our mandate, individual reports on individual cities or provinces -- no blame -- just the facts -- salute administrators for job done with the shrinking dollar portion of the tax pie.

We will not promote product, that's up to the saleman, but we can provide the market place by convincing the public of the need and in time ensuring action by the politician.

It took our neighbors to the south some 13 years to have their program, TRIP/U.S.A., become effective.

We're there now, on the verge of success with some small accomplishments already

behind us -- Prince Edward Island, Newfoundland, New Brunswick, Ontario and Manitoba.

But we can't stop now just when we're beginning to make an impact.

A meaningful contribution to TRIP/Canada could ensure two things. A boost to an industry in the throws of a six year depression, and a meaningful attempt to assure that those assets we and our fathers have paid for with our tax dollars -- the infrastructure -- will be protected.

ANAEROBIC FILTERS FOR SEWAGE TREATMENT IN SMALL COMMUNITIES

by

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INTRODUCTION

Sewage treatment for small communities is an expensive venture when one considers treatment on a cost per unit volume basis. In the past few years, many communities have been looking for alternatives to the centralized activated sludge facility or the lagoon in an effort to reduce both the capital and the operation and maintenance costs. Used either on-site, in clusters, or as a centralized facility, the anaerobic filter may be that alternative.

Anaerobic treatment processes have typically been used for the treatment of high strength organic wastewaters and sludges, but recently these processes have been considered for the treatment of lower strength municipal sewage. Resistance to the use of the anaerobic process for such an application has come primarily from those who feel that the biological process would fail for two reasons: low temperatures experienced during a Canadian winter; and, low strength influent wastewater. Research undertaken in Yellowknife, NWT[1] has shown, however, that while the biological process in an anaerobic filter does fail in the traditional sense at temperatures approaching 10° C, the anaerobic filter still continues to produce an effluent approximating secondary quality for both organic and bacteriological parameters.

This paper describes the anaerobic filter, discusses its advantages and disadvantages, and describes effluent quality at a range of temperatures.

THE ANAEROBIC FILTER

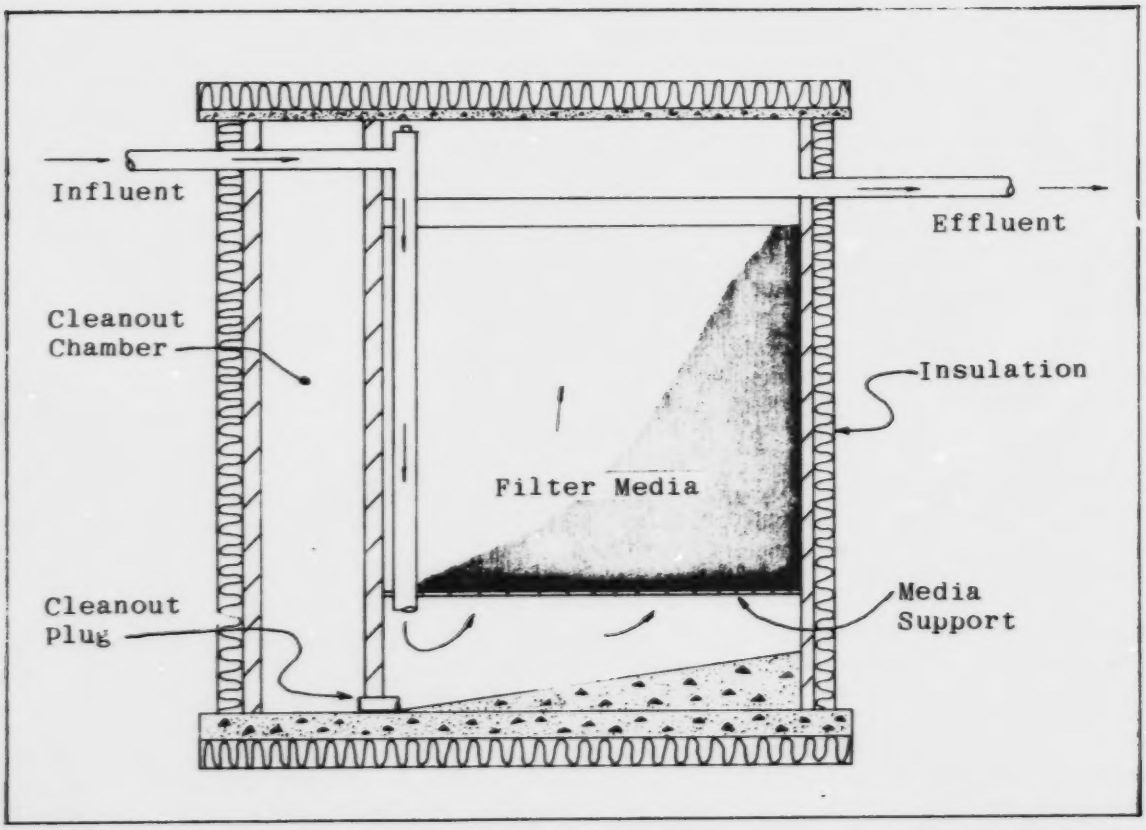
Sewage lagoon treatment is often considered to be the best practical technology for domestic wastewater treatment in small communities. For example, the Northwest Territories Water Board bases its municipal effluent guidelines on expected effluents from sewage lagoons[2]. Recent findings, however, indicate that lagoons may provide an environment for microorganisms to acclimatize to colder temperature waters by allowing them to escape thermal shock. Environment Canada[3] reported that indicator persistence was 2.7 to 5.4 times longer in arctic rivers than previously found for southern winter conditions. (Southern is assumed to indicate those areas where the mean annual temperature exceeds 0 °C.) Reported experiments showed virus survival of 40 to 90 days at 3° C to 5° C under laboratory conditions. Environment Canada concluded that microbes remain viable for extended periods in cold climate lagoons and that large numbers of pathogenic bacteria and viruses are therefore discharged to the environment. In

addition, some microorganisms are becoming increasingly resistant to antibiotics and chlorine is only marginally useful for their destruction[4]. Resistance can be transferred to other organisms simply by contact. Lagoons provide an ideal environment for acclimatization of the organisms to the effluent environment and for transference of resistance[3].

The anaerobic filter does not provide an environment for microorganism acclimatization. This filter consists of a reactor filled with a solid medium which, in turn, supports microbial growth. The medium may be rock, crushed stone, gravel, or various artificial packing materials. The reactor is normally operated in an upflow configuration to ensure that the medium remains submerged, thus maintaining anaerobic conditions. A typical filter design is shown in Figure 1. The reactor may also be configured in a horizontal or downflow mode.

FIGURE 1

ANAEROBIC FILTER
Upflow Configuration

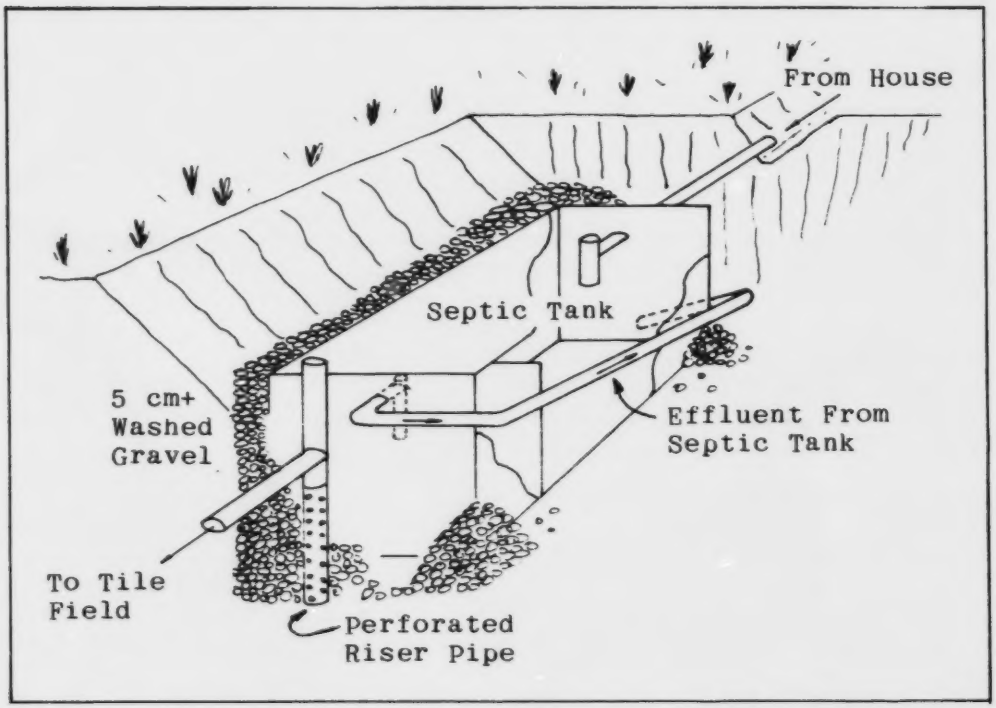


The anaerobic filter has been studied for the on-site treatment of septic tank effluent and sanitary wastewater. Laboratory studies normally involve vertical columns of various configurations, while pilot plants and full-scale designs have been as simple as a pit filled with rock.

A very simple design used for on-site treatment requires only a slight modification to the installation of a standard septic tank[5]. Gravel is filled in around the annular excavation space to the depth of the septic tank and the effluent is piped around the tank to the influent side of the excavation, as shown in Figure 2. Depending on soil characterists, an impermeable liner may be installed to prevent seepage. The waste stream filters through the rock medium towards a perforated riser pipe located near the original septic tank outlet. Two of these so-called "wrap around" filters have been experimentally installed in the State of Washington and have been operating satisfactorily for almost three years[5].

FIGURE 2

WRAP AROUND ANAEROBIC FILTER



The anaerobic filter has been proven successful in various locations throughout the world for treating both sanitary wastewater and septic tank effluent as shown in Tables 1 and 2. Filters operating in colder climates do not seem to function as well for organic removal when compared to those in warmer climates, although the reasons for this are difficult to explain when compared to the Yellowknife experimental data[1] that showed effluent quality in the range of 30 mg/l BOD; 10 mg/l suspended solids; 10,000 counts/100 ml faecal coliform; and 10,000 counts/100 ml faecal streptococci. In the majority of cases this apparent problem is not serious as the effluent is disposed in a tile field. The increase in quality over septic tank effluent, however, would make the effluent more amenable to disposal in more marginal soils (that is, soils with a high water table or poor treatment capacity).

TABLE 1

FULL SCALE ANAEROBIC FILTER TREATMENT OF SANITARY WASTEWATER AT VARIOUS LOCATIONS[5]

LOCATION	WASTEWATER CHARACTERISTICS (mg/l)	LOADING RATE $kg/m^3.day$	HRT (h)	TEMP (°C)	PERCENT REMOVAL
India	BOD - 220 SS - 272	0.01 (BOD)	6	30	79.5 88.5
USA	BOD - 220	0.24 (BOD)	10	10 - 25	55
India	BOD - 175	0.26 (BOD)	5	28	73
India	BOD - 210	0.23 (BOD)	-	31	80

TABLE 2

FULL SCALE ANAEROBIC FILTER TREATMENT OF SEPTIC TANK EFFLUENT AT VARIOUS LOCATIONS[5]

LOCATION	WASTEWATER CHARACTERISTICS (mg/l)	LOADING RATE $kg/m^3.day$	HRT (h)	TEMP (°C)	PERCENT REMOVAL
India	BOD - 240	0.02 (BOD)	144	-	71
Thailand	COD - 310 SS - 170	0.5 (COD)	24	-	60 70
Washington State	BOD - 103 SS - 67 COD - 305	0.04 (BOD)	38.4	-	28 42 23
Washington State	BOD - 120	0.19 (COD)	19	12	28

Anaerobic filters also offer a biological advantage over septic tank waste stabilization techniques. This process achieves more efficient waste stabilization than other processes by converting long chain organics to simpler forms, which are in turn removed from the wastewater as methane and carbon dioxide rather than as fixed cells. This results in low waste sludge production.

The anaerobic filter can achieve a high level of disinfection of the waste stream. Polprasert and Hoang[7] reported an effluent almost free of bacteria after a four day retention period. Bacteriophages (viruses which are parasitic to bacteria and have been used to estimate viral removal rates) were removed to a lesser extent, however, as five of eight samples still contained 100 to 1000 MPN/100 ml. Raman and Khan[8] reported that the removal of helminth ova (the eggs of parasitic worms) was almost 100 percent in most of their laboratory and field experiments. Kent[1] reported up to two orders of magnitude faecal coliform removal and three orders of magnitude faecal streptococci removal after a two day retention period at 10° C.

Anaerobic filters should therefore be further examined as an alternative to lagoons, especially where a concern is held for the downstream bacteriological quality.

ADVANTAGES OF THE ANAEROBIC FILTER

The advantages of the anaerobic filter are as follows:

a) simplicity in construction, operation, and maintenance[6,8];
b) more efficient waste stabilization than a septic tank[6,8];
c) in combination with a septic tank, reduces the volume of solids discharged to a tile field, thereby increasing tile life[6,8];
d) no external power required[5,6,8];
e) low head losses (less than 15 centimetres)[5,6,8];
f) long solids retention times afford a high level of treatment without long hydraulic retention times[6,8];
g) efficiency unaffected by intermittent or transient nature of the flows[6,8];
h) rapid recovery from negative actions such as passing air through the media, permitting the pH to drop as low as 5.5, or allowing the filter to stand idle for weeks or months[5,8]; and

DISADVANTAGES OF THE ANAEROBIC FILTER

The disadvantages of the anaerobic filter are as follows:

a) longer process start-up time[6,8];
b) filter clogging may occur after one or two years of continuous operation[8];
c) process may not consistently achieve a BOD_5 effluent quality better than 30 mg/l[6]; and
d) long solids retention times do not allow the process to adjust rapidly to environmental changes, such as, influent wastewater characteristics and internal temperature[6,8].

CONCLUSIONS

The anaerobic filter may be a viable alternative to the high cost of sewage treatment for the small community. Used either on-site, in clusters, or as a centralized facility, it can provide a low-maintenance and easily-operated system amenable to both land and receiving water disposal.

In northern Canada the large assimilative capacity of the receiving environment often allows for an effluent which does not always meet secondary quality standards. The anaerobic filter may be the mechanism to achieve the level of treatment required for the maintenance of public health in these communities.

Anaerobic filters provide an unfavourable environment for the survival of pathogenic organisms. Effluents from this process may be superior to those of lagoons for the maintenance of bacteriological quality in downstream waters.

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EXCAVATION AND SHORING SAFETY IN MANITOBA

by

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1. Shoring and Excavation in Manitoba 1960-1963:

During this period, there was an increase in the sewer and water facilities being provided in the City of Winnipeg and satellite municipalities as well as the larger towns and villages throughout Manitoba. Along with this increase in services, there was an alarming number of serious and fatal accidents in excavations. At that time, shoring regulations were under the Building Trades Protection Act. The few regulations pertaining to shoring were either confusing or inadequate for the Sewer and Water Industry in Manitoba and in particular the soils found in the Red River Valley.

An example being that if the walls of an excavation were to be sloped, they must be ten degrees greater than the angle of repose of the soil. The interpretation of this requirement under field conditions was the greatest single factor that lead to fatalities from cave-ins. The other regulation that led to cave-ins with their accompanying fatalities was that wood shoring should be placed four feet on centre. The soil in the Red River Valley was unrelenting and in deeper excavations, workers were buried while trying to shore and if they did get the shoring in, they were often trapped by the soil caving in between the shoring.

As a result of all the fatalities and injuries and the extremely high compensation costs to the Sewer and Water Industry a joint committee was set up to regulate the industry.

2. In 1963, the Tripartite Committee was set up to study the excavation industry and come up with Regulations to safeguard employees. This Committee was composed of Excavation Employers, Excavation Workers and Department of Labour Construction Inspection Staff.

The major changes were:

a) That all contractors excavating trenches or shafts more than two metres (six feet) in depth or open diggings more than 2.4 metres (eight feet) in depth where workers had to enter, must notify the department prior to excavating and secure a permit number for the excavation project. The contractor had to provide the name of the owner, the location of the excavation, the type of excavation, the type of shoring to be used, the advising of other utilities, the name of the supervisor and the time and date of starting the excavation.

b) The maximum distance between shoring uprights in good soil was to be 1 metre (3 foot) on center and the minimum size of shoring members was to

be 5 cm (2 inch) by 20 cm (8 inch) full size material.

c) The minimum slope of excavation walls where sloping was used was to be not less than 45 degrees.

d) Where a combination of sloped walls and vertical walls were used, a trench cage must be used in the straight cut portion and the sides of the trench cage must extend a minimum of two feet above the 45 degree slope or the surface to prevent materials from falling into the cage.

e) Trench cages were to be designed by a professional engineer and were to be able to withstand 11.1 kPa per metre (75 lbs. per square foot per foot) of depth to a maximum of four-fifths of the depth of the cage.

f) A Code of Practice with diagrams of shoring was made available to excavation workers. This Code of Practice was updated in 1980 to include confined entry.

As a result of these changes, the numbers of serious accidents and fatalities dropped dramatically and with the exception of the fly-by-night operators and the untrained agricultural people who bought a backhoe and became instant contractors, the industry became more safety conscious with a resultant drop in compensation costs.

3. In 1964, we had a very wet tunnel project and were faced with the use of compressed air. With the aid of the Department of Health, a comprehensive set of standards and medicals was set up for workers in compressed air and the same standards are in use to this date. We have had three compressed air projects over the years and have not recorded an injury due to the use of compressed air.

4. The City of Winnipeg has an extensive system of storm sewers that have been put in by the shaft and tunnel system. There are two methods used to construct the storm sewers:

a) One method is to excavate a shaft using timber walers and 7.6 mm (three inch) thick planking and then to hand excavate either way and to pour concrete usually in 2 to 3 metres (six to ten foot) pushes. The tunnel is crown shored with 7.6 mm (three inch) planks and all tunnels over 2 metres (six feet six inches) in diameter also require face shoring. All materials are moved by a system of buckets and battery operated locomotives on railway tracks and hoisted to and from the surface by means of a crane. All of this type of work is being done on the piece work basis and the employees have become very proficient. Safe work procedures in the English, Portuguese and Italian languages have been established for this industry and serious or fatal accidents are a rarity.

b) In the past ten years, we have had a mechanical system of putting in storm sewers used with relatively good success. This method commonly referred to as the Mole System, incorporates the use of a shaft and a machine called a mole which mechanically digs the earth which is then conveyored onto buckets hauled by a diesel locomotive and taken to the surface at the shaft by means of a crane. The mole advances, usually in 1.5 metres (five foot) stages, and the whole of the shaft is ring shored

with 7.6 cm (three inch) material supported in the webb of steel 3-piece walers. The mole is followed at two to three hundred metres by the concrete forming and pouring crew. On a good day, the mole can advance anywhere up to 30 metres (one hundred feet). One company has changed the digging portion of the mole to enable excavation in boulder impregnated hard pan. This method is a trade secret and will not be discussed here. With the use of diesel locomotives, there has to be a constant fresh air ventilation system employed. All work stations are monitored and the maximum allowable concentrations are three parts per million nitrous fumes and twenty-five parts per million carbon monoxide. Oxygen is maintained at 20 per cent or better.

5. Some reasons why workers enter unshored excavations:

a) Untrained and unaware of hazards.

b) The ground has stood up and not caved in for a long stretch.

c) There is frost in the soil.

d) There are tree roots in the soil.

e) The job will only take a moment (such as probing).

f) There are too many other services in the way.

g) I know the soil and it won't move.

h) The company didn't send the proper shoring.

i) The company expects too much work and I can't get it done if we shore.

Each of the foregoing complaints have been used and in each case, there have been serious cave-ins and a number of fatalities. A supervisor who looks the other way or knowingly allows unshored excavations is doing no one any favours and is the downfall of any safety program.

6. Future Shoring Improvements Needed by Municipal Authorities:

The greater portion of municipal excavation work is on repair and in backfilled trenches often saturated with water and the shoring method which is usually jacks and planks and plywood, is the same as it has been twenty-five or more years. The greatest problem faced is the workers will enter the trench to probe for the pipe or uncover the pipe prior to installing the shoring because the backhoe still has to excavate as much soil as possible without disturbing the pipe. To overcome this entering of possible dangerous excavations, the following two methods may be employed:

a) For water breaks where most of the pipe is at the 3 metre (nine foot) level, a **prefabricated cage** slightly tapered from top to bottom could be employed. This cage could be suspended from the surface by means of sliding pipe outriggers that would suspend the cage so that a minimum of 2 metres (seven feet) of excavation would be shored. This would allow the workers to be protected while they did their necessary probing, etc. The cage could also have pocket brackets attached on either side and the

ends which would serve as guides for planks which may be placed if necessary, to bolster the shoring in wet or silty excavations.

b) The other method is to use **box type shoring and plywood** whereas the excavation is dug down to the 2 metre (six foot) level and 20 mm (3/4 inch) by 1.2 metres by 2.4 metres (4 ft. by 8 ft.) plywood is placed against the walls and held in place by box walers set 1 metre (3 ft.) on centre starting 0.3 metres (one foot) from the top. This type of shoring would allow the safe installation of shoring down to the 1.8 metre (6 ft.) level and then the backhoe could dig down to the probing level inside of the shoring, additional walers and planking could then be added, if required to complete the repair.

The main thrust of the foregoing methods is to prevent workers entering 2 2 metre (seven to eight foot) unshored excavations to locate pipe prior to the backhoe finishing the excavation.

7. As a result of the new inexperienced contractors entering the industry and the inability of employers in keeping their workers from entering unshored excavations, a new requirement has been added to the regulations and will be in force possibly before the end of 1985.

The new regulation states that all excavation contractors and others that make excavations must be registered and receive a registration number from the Workplace Safety and Health Division. Failure to follow shoring regulations will result in their registration being lifted and they will not be allowed to do anymore excavation work until such time as they can assure the Division that they can perform their work safely.

In summation, employers engaged in excavation work should:

a) Ensure that the workers are trained in safe shoring procedures and have the proper equipment to do their work efficiently.

b) Ensure that the shoring methods used will eliminate as far as is practicable, the reasons a worker may have for entering an unshored excavation.

c) Ensure that there are no exceptions to proper shoring and enforce strict disciplinary measures to supervisor or worker where policy or procedure is not adhered to.

INSTRUMENTATION AND AUTOMATIC PROCESS CONTROL
IT WORKS WELL WHEN YOU KNOW HOW

by

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Instrumentation and automatic control systems represent a mixed blessing to most water/wastewater facilities. However, all the positive results and experiences remove all doubt that this technology serves a very useful purpose. Effective automation is not limited by the technology, it is limited by people. This paper presents the technology and the role played by people to assure its success.

INSTRUMENTATION & AUTOMATIC CONTROL SYSTEMS SERVES SPECIFIC PURPOSES

Table 1 presents an overview of instrumentation and control applications in a wastewater treatment facility.(1) Applications meet specific priorities and objectives:

Priority No. 1 — KEEP THE PLANT OPERATING. All other objectives become secondary. A plant can maintain operation with reliable equipment and processes. A basic control system objective must therefore be to contribute to this reliability. This can be done with functions that prevent process and equipment failures.

Priority No. 2 — MEET EFFLUENT STANDARDS. Control system priorities must include those functions that are in support of this objective. This includes control of flow, solids and ammonia.

Priority No. 3 — REDUCE COSTS. Only when reliability and performance are under control can we concern ourself with the economic issues.

The Table makes references to actual experiences reported in the literature. Reference 1 provides an expanded overview.

TABLE 1

Control System Objectives Match
Treatment Plant Operational Objectives
References Demonstrate Reported Experiences(1)

Plant Priority Number	WWTP Objective	Control System Objective	Examples of Solutions
1.	• KEEP PLANT OPERATIONAL	IMPROVE RELIABILITY:	
		A. Avoid process failure	• Sewer system feedforward to plant operations
		B. Avoid equipment failure	• Detect impending failure
			• Predictive maintenance analysis by continuous monitoring
2.	• MEET EFFLUENT STANDARDS	IMPROVE PERFORMANCE:	
		A. Effluent quality control	• Control flow, solids, ammonia
		B. Receiving water quality	• River DO as feedback
		C. Odor prevention	• Dewater sewers periodically
		D. Minimize combined sewer overflow	• Storage control with optimized digital control
		E. Improved sludge settleability	• Automatic DO control
		F. Prevent hydraulic upsets	• Automatic pumping control
3.	• OPTIMIZE PLANT OPERATIONS	REDUCE COSTS AND IMPROVE CAPACITY:	
		A. Energy reduction	• DO and pumping control
		B. Chemical reduction	• Chlorine, lime, polymers, and ferric feed advanced control strategies
		C. Staff reduction	• Centralized operations and automatic control
		D. Require less process capacity and/or smaller equipment size	• Excess plant capacity trade off with optimized digital control (ODC)
		E. Delay expansion	• Implement DDC
		F. Improved capacity	• Implement advanced digitally emulated analog control and ODC

INSTRUMENTATION WORKS WHEN SPECIFIC PREREQUISITES ARE MET

The author conducted a survey on instrumentation experiences. The results were mixed (Table 2). However, we miss the point if we accept the results at face value. Add personal experience to the survey results and the picture changes.

TABLE 2

Survey Results show that experience with analytical instrumentation is a mixed bag

	Totally Satisfied	OK	Dissatisfied
pH in pressurized system	29%	42%	29%
pH in open tanks	22	44	34
Residual chlorine	47	20	33
Suspended solids in pressurized system	10	20	70
Suspended solids in open tank	14	28	58
Dissolved oxygen	33	27	40
Magnetic flow meters	47	35	18
Venturi tubes	35	44	21
Parshall flumes	50	44	21

We know for a fact that the instruments work to some peoples' total satisfaction. Understanding the distinction between successes and failures should point to the problem. For example: identical DO probes work with minimum maintenance in St. Paul, MN - and fouls within 2 hours in Porland, OR; magnetic flow meters have proven their worth in thousands of installations, yet 18% of those surveyed are totally dissatisfied. We know that numerous instruments don't meet their own specifications. More than 50% of instruments tested at SIRA (an English instrument testing institution) did not meet specifications after 3 months in operation[2]. An instrument will provide user satisfaction when four prerequisites are met:

- It performs in accordance with its specifications
- It is correct for the application
- It is properly installed
- It is properly operated and maintained

Here is what is needed:

- A test report prepared by an independent testing institute
- A procurement requirement for independently certified test data
- Receiving inspection and calibration prior to installation
- Calibration data for all in-line flow meters
- Instrument selection based on process and ambient conditions
- Installation design that recognizes requirements for proper operation and ease of maintenance/calibration
- Prequalification of acceptable equipment in in-situ acceptance testing
- Detailed plans to enable the construction inspector to verify that requirements are met

Design requirement examples are included in the Appendix for various instruments.

COMPUTER-BASED CONTROL SYSTEM RESULTS ARE SIGNIFICANT

Survey results showed that 83% reported improved process reliability, 33% reported improved plant equipment reliability, 78% reported improved process performance and 17% reported they could not meet the effluent standards without their computer system[1].

Fifty percent reported an increase in plant capacity, 28% reported energy savings ranging from 10 to 25%, 22% reported reduction in chemical usage from 15 to 30%, and 50% reported reduction in staff requirements, all as credited to their computer monitoring and/or control systems[1].

Not everything is this rosy, however. Some computer systems did not work, others were far short of meeting the owners expectations. The reasons are many, but the common factors are people in all cases.

Quality can be defined as meeting requirements. Control systems will meet requirements when:

- They are designed to meet predefined objectives
- They are supplied by qualified vendors who receive a fair price
- The processes/equipment to be controlled are designed with automatic control objectives in mind
- The owner accepts responsibility for the control systems, expects results from the system, and provides adequately trained staff with a charter for specific results

Process performance can be measured and reported. Control system performance can also be measured and reported. We suggest that reports on performance can enhance everyones awareness of value. Parameters may include:

- System uptime/availability
- Number of loops on automatic, how long
- Number of control strategies on automatic, how long
- Instruments out of service, reason, effect
- Performance [instrument calibration, control loop dynamic performance (for example, integrated value of the error signal)]

Treated as objectives with specific targets, deviations must be cause for management action.

SUMMARY

Instrumentation and control systems represent a very large topic with technological and social complexity. The informed user can achieve very significant results, yet he/she doesn't have to be an expert on the technology. The user must, however, understand the results he/she wants to achieve.

This text presented, but briefly, some of the results and experiences that have been reported, some of the problems and some of the solutions.

The references and bibliography are presented as worthwhile reading for those who want to understand what can be achieved and how to go about assuring results.

The appendix represents selected excerpts from the Wastewater Treatment Plant Instrumentation Handbook[4]. It will be available from the National Technical Information Service (NTIS) in late 1985.

The conference presentation provides background in instrumentation, process control and computer system technology. It concludes with a case study which is documented in reference 3. Material marked with an (*) is available from the author.

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APPENDIX*

A. Dissolved Oxygen Measurements

Designer Checklist

Ask the following questions when designing or reviewing dissolved oxygen meter applications. All checklist questions should be answered "yes".

1. If a non-membrane probe is being considered, is the process stream's conductivity greater than 100 micro-mhos? Is the conductivity stable?
2. Are interfering dissolved gases absent (chlorine, hydrogen sulfide, carbon dioxide, and sulfur dioxide)?
3. Does the process fluid wash the probe at a rate greater than 30 cm/s (1 ft/s)?
4. Does mounting eliminate the possibility of air bubbles being trapped at the measuring surface?
5. Does the probe see a sample representative of the process?
6. Is the probe mounted securely without causing likely collection sites for debris?
7. Can the probe be removed easily for inspection or maintenance?
8. Is installation of the meter designed so one person can calibrate it?
9. Is the transmitter protected from the weather where necessary?
10. Does the meter have automatic temperature compensation?
11. Is the probe installed so it is always immersed in the process liquid?

Maintenance and Calibration

1. Membrane probe meters.

Task	Frequency
a. Clean membrane	Depends on process stream characteristics. Some membrances must be cleaned daily; but more typically, every two days or once a week. Membrane breakage is a common problem. To reduce cleaning time, check calibration with a portable DO probe and clean membrane only when the two meter readings differ by more than 0.5 mg/l

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* Selected excerpts from the Wastewater Treatment Plant Instrumentation Handbook by R.C. Manross. USEPA Contract 68-03-3130

Task	Frequency
b. Replace membrane	Whenever membrane breaks or when electrolyte is replaced.
c. Electrolyte Replacement	Every three to six months.
d. Calibration to portable probe	Every other day.
e. Air calibration	After membrane cleaning.
f. Calibration to standard	On initial installation or after major repair.

2. Non-membrane probe meters.

TASK	FREQUENCY
a. Inspect and clean grindstone	Every two months.
b. Replace grindstone	Every six months.
c. Calibrate to Standard	Weekly or bi-weekly are typical calibration intervals.

Deficiencies

The following problems are commonly reported for dissolved oxygen meters.

1. Agitator or cleaner becomes fouled with hair or fibers. Where possible, avoid use of agitators, mechanical cleaners, probe guards or shields.

2. The probe becomes fouled within a few hours due to process stream characteristics such as grease or slime growth.

3. The probe cannot be withdrawn from the process stream because of mounting.

4. One person cannot calibrate the probe because of the mounting bracket, difficult alignment, or awkward mounting.

5. The probe cannot be calibrated by one person because the transmitter is too far from the probe and no remote calibration unit is installed.

6. The probe is placed in a "dead" area of the tank. Poor mixing with the rest of the tank results in a false signal that does not show the true state of the process.

B. Magnetic Flow Meters

Designer Check List

Use the following checklist when designing or reviewing magnetic flow meter

applications. Verify affirmative all checklist items for proper application and installation.

1. Does the process liquid to be measured have a measured conductivity greater than 5 micro-mhos per centimeter?

2. Will the pipe flow full under ALL conditions, excluding shutdown?

3. If intermittent flow is expected, will the meter remain full at no flow? Does the transmitter have low flow zero cut-out circuitry?

4. Does the meter size ensure a flow velocity between 1.5 - 7.5 m/s (5-25 ft/s) for solids-bearing liquids or 1-9 m/s (3-30 ft/s), for non solids-bearing liquids?

5. Has the proper liner material been selected for the particular application?

6. Do the electrodes require and have continuous cleaning capabilities?

7. Are all piping elements/obstructions located at a minimum distance of five pipe diameters upstream or downstream of the meter?

8. Have grounding rings and straps been provided, and is the meter grounded to a true ground?

9. Have bypass piping and valving been provided?

10. Is signal wiring between the transmitter and meter as specified by the meter manufacturer and routed in separate conduit?

11. Has a dedicated power source been provided for the mag meter?

12. Has the proper electrode material been selected to avoid excessive wear?

13. Is the selected liner material compatible with the expected operating temperature?

14. Does the design provide environmental temperatures within the range specified by the manufacturer for both the meter tube and the transmitter/converter?

Acceptance and Performance Monitoring

Include provision for acceptance testing and performance monitoring relating to:

1. Hydraulic flow testing,

2. Electrical ground testing, and

3. Verification of manufacturer accuracy and factory calibration documentation.

Maintenance and Calibration

Task	Frequency
1. Calibrate transmitter	Once each month.
2. Flow calibrate the meter	Every three months.

Deficiencies

The following problems are commonly encountered with existing mag meter installations.

1. Velocity skewing created by piping obstructions located too near to the meter causes accuracy problems and liner wear. In severe cases the obstructions cause the liner to be ripped away.

2. Meter sizing does not maintain adequate flow velocities. Often this results from over design for "future" flow rates.

3. Improper installation results in non-full pipe during low flows.

4. Solids coating the electrodes due to lack of automatic electrode cleaning cause low flow velocity and/or intermittent flow.

5. Meter and/or transmitter located so that calibration and maintenance accessibility are difficult.

6. Isolation and bypass piping is not installed, requiring shutting down the process for meter zeroing and meter removal (when required).

7. Infrequent calibration.

8. No provisions are made for meter calibration.

9. Improper grounding.

C. PARSHALL FLUMES

Designer Checklist

Use the following checklist when designing or reviewing Parshall flume applications. All items should be verified affirmative for a correct application and installation.

1. Has the smallest practical Parshall flume been selected for the anticipated range of flows?

   a. As a guide, the maximum flow expected should fall within 70-100% of the maximum capacity for the selected flume size.

   b. A depth of at least 0.015 m (0.5 in) should exist at the minimum actual flow.

2. Is the flume floor elevation high enough (relative to downstream conditions) to prevent submerged flow?

3. Does a sufficient straight run of pipe or channel exist upstream?

4. Will the upstream flow be non-turbulent and wave free?

5. Do any downstream obstructions exist which could cause a restriction to the discharge of the flume?

6. Is a depth gauge included for calibrating the flume?

7. Is the level sensor correctly located on the flume?

8. Is the level sensor zero correctly referenced?

9. If required for the application, is a stilling well provided?

10. The following items pertain to the stilling well:

    a. Is the vertical height extended below and above the anticipated operating depths in the flume?

    b. Is the flume opening for the stilling well sized large enough to avoid sensor lags and plugging?

    c. Has the flume opening been correctly located on the length of the converging section wall?

    d. Is the flume opening positioned below the lowest flow operating level?

    e. If the flume is used to measure raw sewage or mixed liquor flow, has a water purge been piped to the stilling well?

Acceptance and Performance Monitoring

A depth gauge mounted on the converging section is recommended so manual readings and flow calculations can be made to check remote flow indicators or recorders.

Other methods for flow verification and testing are described in Reference 4, Section 7.1.

Maintenance and Calibration

1. Parshall Flume.

    a. Weekly, check the depth gauge with other level flow indications for the flume to determine if calibration of the secondary system is required.

    b. Periodically, wipe down the flume walls to remove slime or other buildup.

c. Check for bottom deposits and remove as required.

d. Quarterly, check the zero of the reference depth gauge.

e. Semiannually, examine the flume surfaces for signs of deterioration and wear.

2. Stilling well (if used).

a. Periodically, check for solids accumulation and clean as necessary (establish the interval between checks by experience).

b. If a water purge is used, check it daily and adjust the flow rate as needed.

Deficiencies

The following problems are encountered in existing Parshall flume installations:

1. Insufficient straight channel upstream, resulting in non-uniform velocity distribution through the throat.

2. Sloping floor in the converging section.

3. Low flume floor elevation (relative to downstream channel level) resulting in submerged flow condition.

4. Measuring the depth of the hydraulic head at the wrong location.

5. Using an incorrect equation for calculating flow from level.

6. No provisions for purging the stilling well when measuring a solids-bearing stream (buildup of deposits in the stilling well renders the level sensor inoperable).

7. The foundation is not water tight, allowing leakage under or around the flume.

8. Flume sized too large for the operating flow range.

D. BUBBLER TYPE LEVEL MEASUREMENT

Designer Checklist

Ask the following questions when designing or reviewing bubbler level meter applications. All checklist questions should be answered "yes".

1. Can air be passed through the process fluid? If not, can another gas, such as nitrogen, be substituted for air?

2. Is the tank open or vented? If not, is accumulation of air acceptable?

3. Are head losses from the air flow regulator to the bubble tube minimized?

4. Is the purge line length from air flow regulator to the bubbler tube less than 15 m (50 ft)?

5. For process streams containing more than about 100 mg/l suspended solids, is automatic purging included?

6. Does the air supply reliability match the need for level measurement reliability?

7. Is the bubbler tube mounted securely?

8. Is the clean-out tee accessible?

9. Is the bubbler enclosure suitable for its environment?

10. For open tanks, does the pressure transmitter reference the same gas space? For example, a bubbler tube mounted outside and a transmitter mounted inside a building will be exposed to different atmospheric conditions. Can this difference be tolerated?

Maintenance and Calibration

Maintaining and calibrating the differential pressure transmitter is presented in Reference 4, Section 6.2.

Task	Frequency
1. Check air flow	Daily, or if the unit has a low-flow alarm detector, only at calibration.
2. Clean tube	Weekly purge for solids-bearing fluids. Manual cleanout at calibration. Manual cleanout when tube is depressurized and fluid enters.
3. Check air filter	Weekly. If the unit has a low-flow alarm detector, then check filter only at calibration.
4. Calibrate	Every two months.
5. Inspect compressor	Depends on type and size of compressor. Follow the manufacturer's recommendation.

Deficiencies

The following problems are commonly reported for bubbler systems.

1. Compressor failure, and measurement loss.

2. Tube bubbler opening does not stay clean because no purge or cleanout is available.

3. Condensate collection trapped in the purge tubing.

4. Purge tubing lines too long or too small, creating excessive head losses.

5. The bubbler tube tip does not correspond with the desired zero level reference.

TODAY'S NEEDS FOR C.C.T.V. INSPECTION

by

Glenn E. Hood
President
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HISTORY

Closed Circuit Television is old technology dating back 35 years or more. As costs increased for visual inspection, C.C.T.V. has become very popular as a cost effective way of inspecting new systems after installation, to say nothing that C.C.T.V. is much superior to visual inspection. It is also widely used in planning sewer renewals of older systems and evaluating current condition of pipe and infiltration problems.

Today's needs are wide and varied, but basically it is information for the Municipal Engineer and his staff, and the Consulting Engineers. Without valid information, all parties are stabbing in the dark.

Let me ask the following questions: -

> How many of you at the municipal level are using a C.C.T.V. program to evaluate your existing sewer system?
>
> How many of you pave your streets without C.C.T.V. to find out the condition of the services under the road bed?
>
> How many of you have in your bylaws, in the case of the municipality; and in your Standard Specs, in the case of consultants; that all new installation of sewers must be televised prior to acceptance by the owner?

Besides all of the diseases that we hear about every day, such as cancer, etc., we have one in the Public Works field that is, in my opinion, just as serious and it's called "out of sight, out of mind" and it is the direct cause of the chronic condition of our utilities systems in this country. Don't you believe for a minute that it's not a problem in your community because it is.

It never ceases to amaze me, some of the strange, and in some cases, totally unreal stories, we get from people as to why they don't need C.C.T.V. in their community and in many cases from professional people that should know better.

Frankly, these excuses, and that's what they are, will simply not hold up.

One of the favourite excuses is that "our council would never allow T.V. as it is too expensive." First of all, the councillors don't even know anything about C.C.T.V. until you people tell them about it and the merits of C.C.T.V.

Another favourite excuse is, "In all the years I have been here, we haven't had any serious problems." My answer to this one is "where will you be after the Mayor's car disappears into a crevice in the middle of Main Street."

I believe it is one of the responsibilities of the Municipal Engineer to advise and provide leadership to his council on subjects that are new to them.

In respect to expense, C.C.T.V. usually represents something less than 1% of the total cost of an installation.

I will never understand how any thinking person in this field would pave a street not knowing what the conditions of the services are under the street.

In summing up, I hope my message today has inspired at least some of you to look toward using the tools and technology available to you in order that you can do a better job in your chosen career for your municipality or your client, and for the betterment of the community you are serving.

TASTE AND ODOUR CONTROL FACILITIES FOR REGINA/MOOSE JAW WATER SUPPLY

by

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INTRODUCTION

The drinking water in Regina and Moose Jaw, Saskatchewan, has developed a national reputation over the years. Unfortunately, the reputation is for a pronounced musty, grassy, septic smell associated with blooms of various species of blue-green algae in the supply reservoir.

In 1980 the Buffalo Pound Water Administration Board, which operates the plant, embarked on a program to alleviate the taste and odour problem. CH2M Hill was retained to review the water quality as it relates to the production of taste and odour; to study alternative means of reducing the taste and odour; and to develop a plan for implementing the most cost effective solution. Additional work carried out at this time included studies for plant capacity and treatment of plant wastes.

STUDY PHASE

All of Moose Jaw's and most of Regina's potable water supply is drawn from Buffalo Pound Lake, a shallow prairie lake in the Qu'Appelle Valley. The water is treated in a conventional clarification-filtration plant which was originally constructed in the early 1950s and has been expanded twice. Buffalo Pound Lake experiences regular blooms of algae including Anabaena, Microcystis, Aphanizomenon and other taste and odour causing species. In late winter and early spring, Asterionella blooms are common, and they also give rise to a pronounced, unpleasant odour. Threshold odour numbers (TON) for the raw water are typically 15 to 30 in mid-summer.

Organic carbon concentrations as measured by total organic carbon (TOC) are relatively high. The high organic content is a concern because it serves as a food supply for microbial growth in the distribution system and because it is a precursor for trihalomethane production. Chlorination of the water with its relatively high organic content produces trihalomethanes (THMs) which are suspected carcinogens. While the THM levels actually encountered do not exceed the federal and provincial limit of 350 ppb, reduction to levels less than 100 ppb (which is the limit in the U.S.) is considered desirable.

The study focused on three general methods of taste and odour and THM control.

Alternative Intake Site

The costs and benefits associated with transporting water from an alternative site on the lake and from the Qu'Appelle River upstream of the lake were examined. It was concluded that no real improvement would result from an alternative site further upstream in the lake. The costs associated with the Qu'Appelle River intake were excessive because of the distance involved. In addition, an intake in the Qu'Appelle River would require an increase in the total flow released from Lake Diefenbaker.

Alternative Oxidants

During the summer months operation, heavy doses of chlorine are applied at the intake to kill algae and improve their settleability; to satisfy the large chlorine demand; and to carry chlorine residual through the distribution systems. Alternatives to chlorine as a pre-oxidant were considered as a means of reducing THM formation and possibly reducing taste- and odour-causing compounds. Chlorine dioxide, ozone and permanganate were evaluated.

While successful in reducing THMs, none was particularly effective at reducing taste and odour. In addition, chlorine dioxide and ozone had specific drawbacks that made their use impractical. Chlorine dioxide leaves a chlorite residual which is also a health concern. Ozonation causes a severe foam problem on the clarifier.

Supplemental Processes

Several supplemental processes were examined as methods of preventing or removing taste and odour. Dissolved air flotation was tested as an algae-removal process and powdered and granular carbon were evaluated as dissolved organic removal processes. Dissolved air flotation was no more effective than the current practice for algae removal. Both granular and powdered carbon were effective in removing TOC, THM, and taste and odour but granular carbon was more economical and more practical.

Powdered carbon has been used at the plant but with limited success, mainly due to the physical configuration of the plant. If it is added upstream of the clarifiers, there is insufficient residence time for efficient treatment. The odour level of the clarifier sludge is significantly reduced but the water is only slightly improved. If it is added downstream of the clarifiers, the treatment is more effective but a noticeable amount of black fines is carried through the filters to the finished water.

GAC was tested at the plant in 1977-78 by placing 600 mm (2'-0") of the carbon in one filter. Results showed temporary improvement in taste and odour; however, high turbidity and significant carbon losses during backwash [150-225 mm (6'-9") per year] were experienced.

In 1980 granular activated carbon (GAC) was tested in both the up-flow and down-flow modes. Up-flow contactors have the advantage of requiring backwashing less frequently but were found to generate and pass too many carbon fines for acceptable finished water quality. Down-flow carbon contactors were selected for detailed evaluation because of the lower finished water turbidity and the ability to convert them to sand filters.

After an initial bench scale screening, the more promising of the alternative oxidants and new processes were tested in a continuous pilot plant. The pilot plant ran at 2.2 m^3/hr (1 gpm) in the clarification section and 0.22 m^3/hr (1 gpm) in the filter/GAC section.

The pilot plant water supply was delivered through a separate line from the intake pump station to allow testing of water that had not been chlorinated. One test was also run on water from a source upstream of the lake. This was supplied by tank truck.

The pilot plant was an invaluable part of the treatment study. It was the only way to discover the operational difficulties with ozonation; to assess the effectiveness of the alternative oxidants; and to determine the effectiveness and capacity of activated carbon. It is now a permanent installation at the plant and has proved useful in evaluating carbon from different suppliers as well as developing new coagulation/flocculation techniques.

A schematic of the pilot plant in the down-flow GAC mode is shown in Figure 1.

FIGURE 1

Pilot Plant Schematic

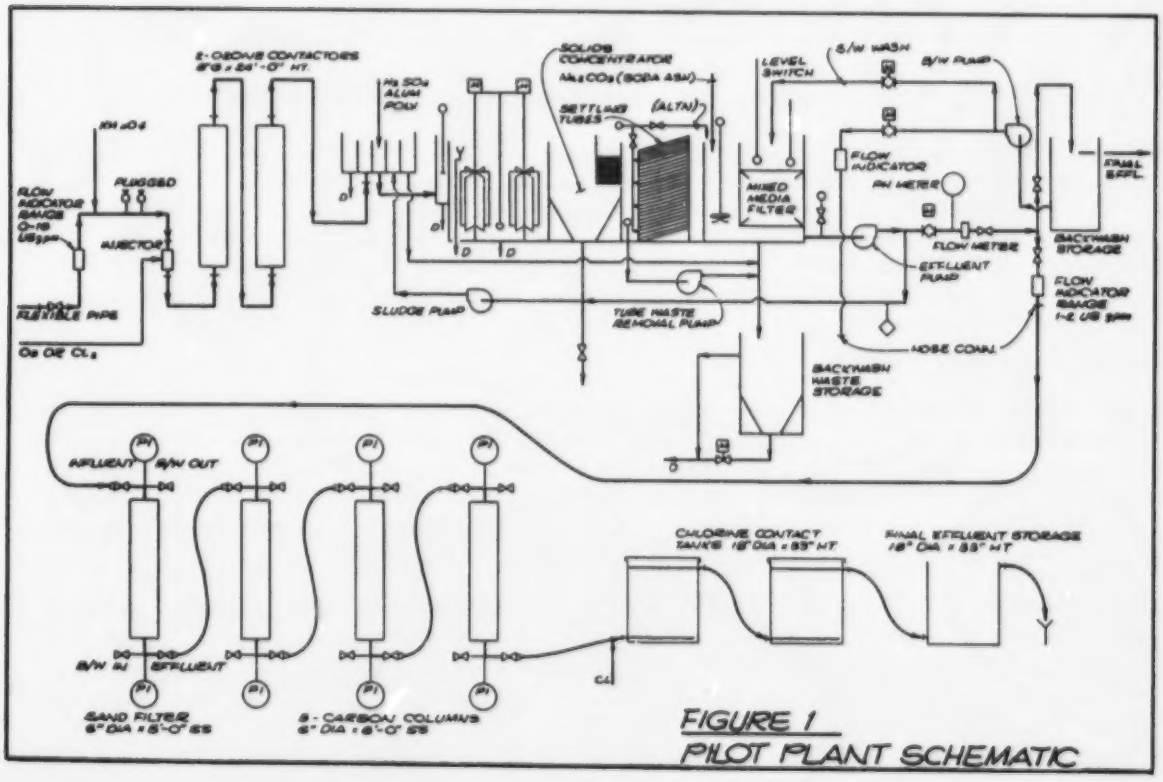


FIGURE 1
PILOT PLANT SCHEMATIC

The conclusions reached at the end of the study phase were GAC adsorption in the downflow mode following filtration produced the lowest level of threshold odour number (TON) and TOC in the finished water; a total of eight GAC contactors, constructed adjacent to the existing filters, would provide taste and odour

control treatment for 32 MIGD; and a carbon handling regeneration facility would allow for reuse of the GAC.

DESIGN OF FACILITIES

Objectives

On the basis of the bench- and pilot-scale tests, the Buffalo Pound Water Administration Board authorized CH2M Hill to proceed with the final design of the GAC facilities.

The design objectives were:

(1) to improve the quality of the water being treated in the plant from a taste and odour perspective. Based on the GAC performance as measured in the pilot runs, the specific water quality objective was to maintain a TON of less than three. However, it was recognized that TON is a subjective measure of acceptability of water quality and, in some cases, water with higher TON values may not be objectionable.

(2) to reduce the concentrations of total trihalomethanes (TTHMs). The design objective was to maintain TTHM concentrations at less than 100 ppb (as measured by the DAI method).

(3) to design the GAC adsorption contactors to be convertible to conventional filters should the source of supply be changed to Lake Diefenbaker at a later date, and to provide additional clearwell capacity in the plant.

Although not a stated design objective, consideration was also given to reducing the dissolved organic content of the water, as measured by TOC analysis. The TOC of the treated water currently varies between 4 and 9 ppm with very occasional higher peaks. Though there are no government standards for TOC concentrations at this time, it was recognized that TOC concentrations of this magnitude are unusually high and may prove to be undesirable.

Granular Activated Carbon

Though carbon has been used for centuries for water purification, its adsorptive powers were not recognized until the late eighteenth century. Records of experiments carried out at that time show that chemists knew of adsorption of gases and organic colouring matter by charcoal (95-98% carbon). Today, activated carbon is extensively used in water treatment, wastewater treatment, and food processing industries to adsorb organic impurities.

Activated carbon is obtained as a residue after the volatile components of carbonaceous materials (coal, lignite, peat, wood) are removed in a controlled thermal process. The most important property of the activated carbon is its pore structure, which consists of very small diameter holes giving the material internal surface areas in the range of 500 to 1500 m^2/gram. This enormous area and high surface activity are the source of the adsorptive powers.

The term "adsorption" describes the existence of a higher concentration of a substance at the interface between a fluid and a solid than is present in the fluid. The affinity of a substance for the internal surface of activated carbon depends on its chemical nature and is usually represented empirically by

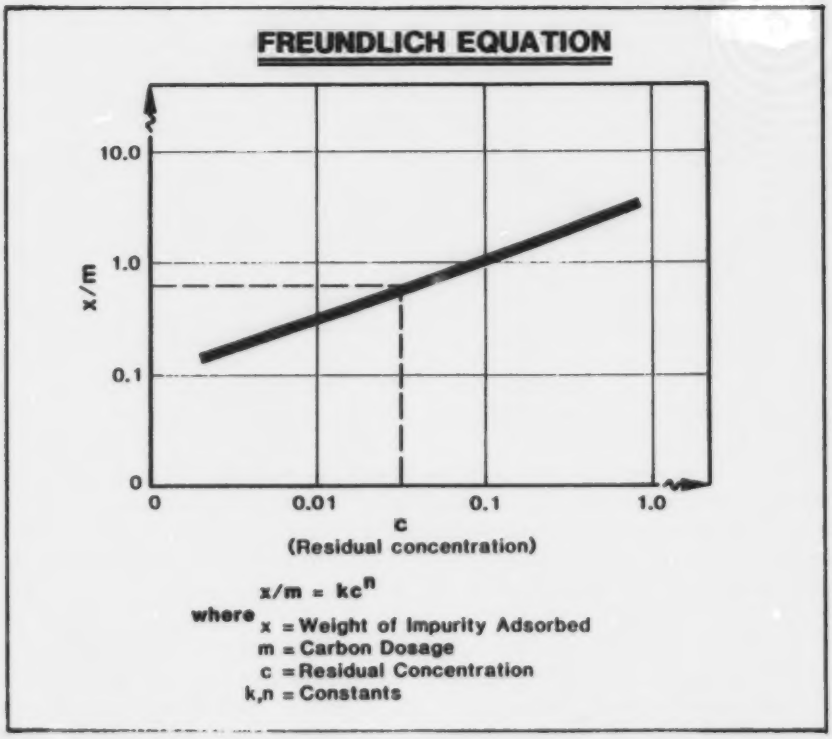
the Freundlich equation which has the following form:

$$x = kc^n$$

where
- x = weight of impurity adsorbed
- m = carbon dose
- c = residual concentration of impurity
- k,n = constants depending on carbon and impurity characteristics

When the Freundlich equation is plotted on a log-scale, a linear relationship is obtained, as indicated on Figure 2.

FIGURE 2

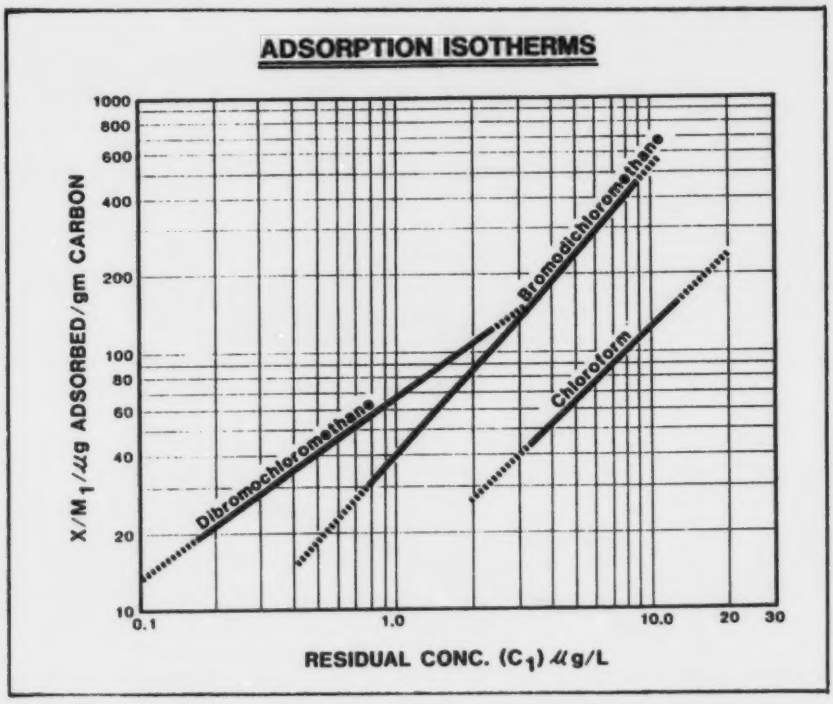


Freundlich plots for specific compounds are obtained experimentally and are called "adsorption isotherms". Figure 3 shows typical adsorption isotherms for three trihalomethanes developed as a result of pilot plant tests at Buffalo Pound and described by Andrews et al.[1] Curves such as those shown on Figure 3 indicate the equilibrium amount of substance adsorbed per unit mass of carbon in relation to the residual or final concentration. With this information the initial effluent concentration of the adsorbate can be determined. However, when granular activated carbon is to be used, pilot column studies are highly desirable to develop final design criteria.

Results of the pilot plant test runs indicated that parallel downflow contactors provided the optimum solution for the Buffalo Pound plant. This system offered the advantages of moderate capital costs, reduced pumping energy requirements, and the facility to meet the objective of relatively easy later conversion to

conventional filters. In this system the influent water is divided equally among the contactors and flows through carbon. The treated effluent from each contactor is then routed directly to the clearwell.

FIGURE 3



Adsorption of organic material from solution is not an instantaneous process. Sufficient contact time between the granular activated carbon and the flowstream must be provided for the adsorption process to occur. When the effluent water flows through a GAC contactor, a zone of active adsorption will exist within the contactor. This zone is often referred to as a "wavefront".

Figure 4 shows how the adsorption wavefront develops in a contactor. Initially, the GAC is in a near-virgin state so the wavefront will be relatively short; this indicates that the concentration of the organic material in the water will be reduced to its equilibrium level within a short distance in the contactor. As adsorption continues, the GAC in the top of the contactor becomes exhausted so the wavefront expands downward, as shown in the second schematic of Figure 4. Finally, the wavefront will move down the contactor maintaining its fully developed stage. Once the wavefront reaches the bottom of the contactor, "breakthrough" is said to occur. The shape of the wavefront is an important design parameter since it determines the minimum bed depth and the portion of the contactor that will only be partially exhausted when breakthrough occurs. The ideal is a flat wavefront curve, which would indicate that the contactor GAC is being uniformly exhausted.

Empty Bed Contact Time (EBCT) is an important parameter in the design of GAC contactors. EBCT is defined as the volume of the contactor occupied by the GAC divided by the influent flowrate, and is a measure of the water residence time in the contactor. Pilot plant operations in the downflow mode provided the

parameters characterizing the capacity of various carbons to reduce TON, TTHMs and TOC. From this data was extrapolated a design for full scale contactors. An EBCT of 14 minutes, provided by a contactor volume of 172 m^3 (6074 ft^2) [4.3 m (14 ft) width, 13.6 m (44.6 ft) length, 3.0 m (10 ft) carbon depth] and flow throughput of 430 $m/^3/hr/m^2$ (5 USGPM/ft^2), was chosen as providing the optimum sizing to meet the objectives of the project. The design of the facility was based on conditions of the project. The design of the facility was based on conditions expected during a "bad" year with respect to taste and odour in the water. In such instances, carbon adsorption will likely be necessary on an almost year-round basis to meet the taste and odour control objective. During an "average" year, carbon treatment will likely be required for only three to five months during the summer when algae growth and the resulting taste and odour problems are at a maximum.

FIGURE 4

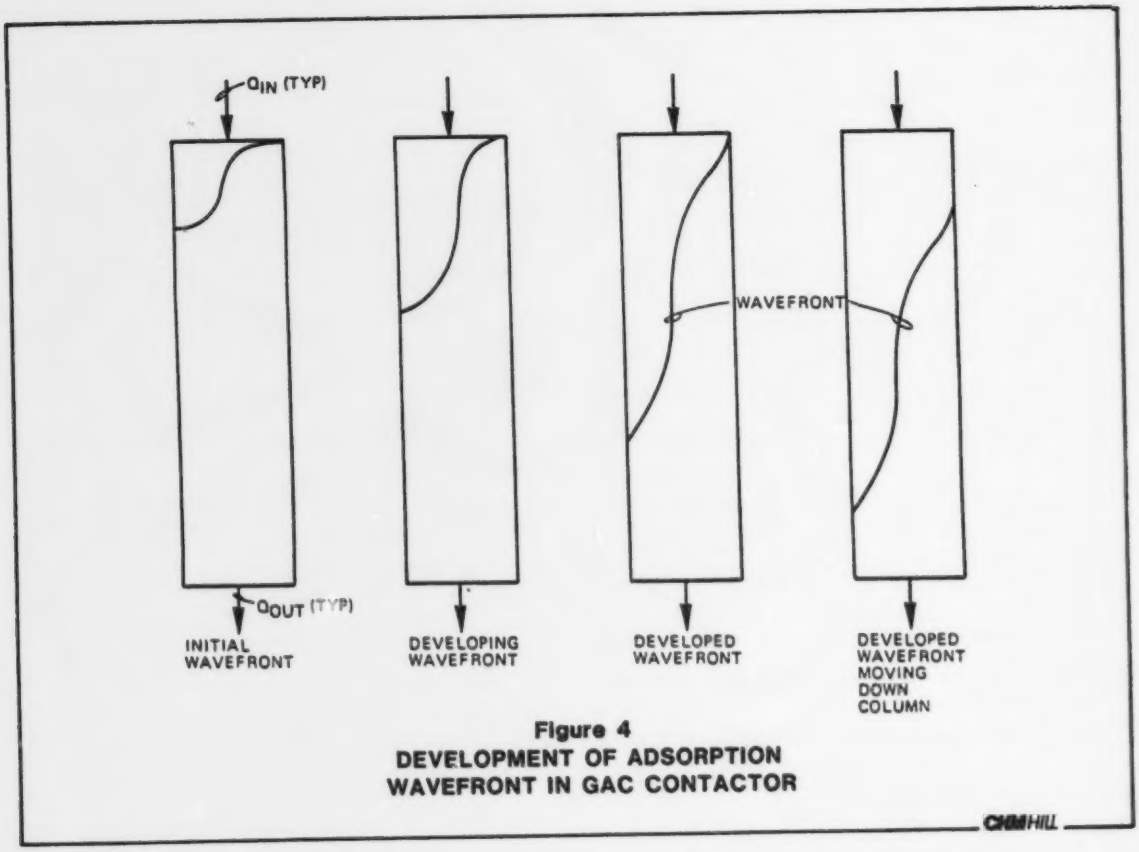


Figure 4
DEVELOPMENT OF ADSORPTION WAVEFRONT IN GAC CONTACTOR

Carbon Contactors

Figure 5 shows a site plan for the Buffalo Pound Water Treatment Plant. The GAC treatment facilities are located south of and directly connected to the existing building. The regeneration building, which houses the regeneration furnace and ancillary equipment, storage tanks and laboratory, is located further to the south and connected to the main building by means of an underground access tunnel. Also shown on Figure 5 is a plan view on the contactor layout.

FIGURE 5

Site Plan and Building Layout

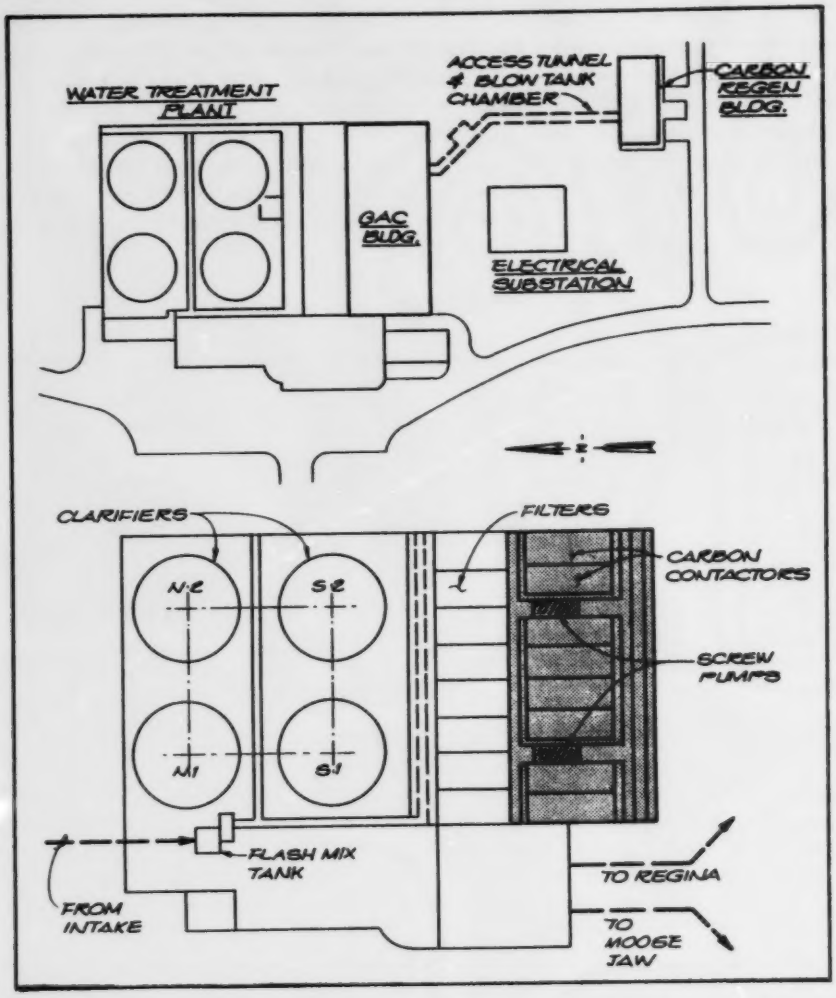


Figure 6 shows an overall process schematic of the plant.

Figure 7 shows the contactor internals and face piping.

Treated Water System

Water from the mixed media filters is delivered to a 1050 mm (42 in) header connected to the filter underdrains at the south wall of the existing building. The header delivers water to wet wells at the two screw pumps. These screw pumps [diameter 2.44 m (8 ft) motor size 250 HP, weight 12,000 kg (26,000 lbs)] elevate the water approximately 5 metres (16.4 ft) to an inlet channel. Archimedes screw pumps are ideally suited to the high-volume, low-head application and have the added feature of requiring no flow controls. If the water level in the wet well rises, the pumped volume increases proportionately.

FIGURE 6

Buffalo Pound Water Treatment Plant Schematic

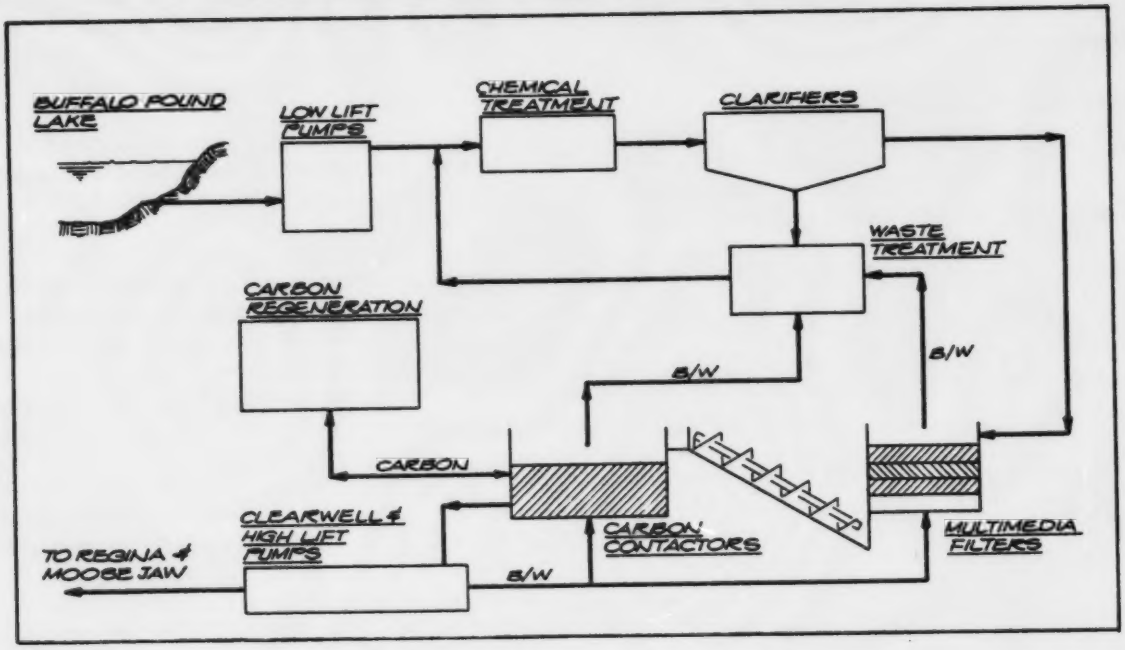
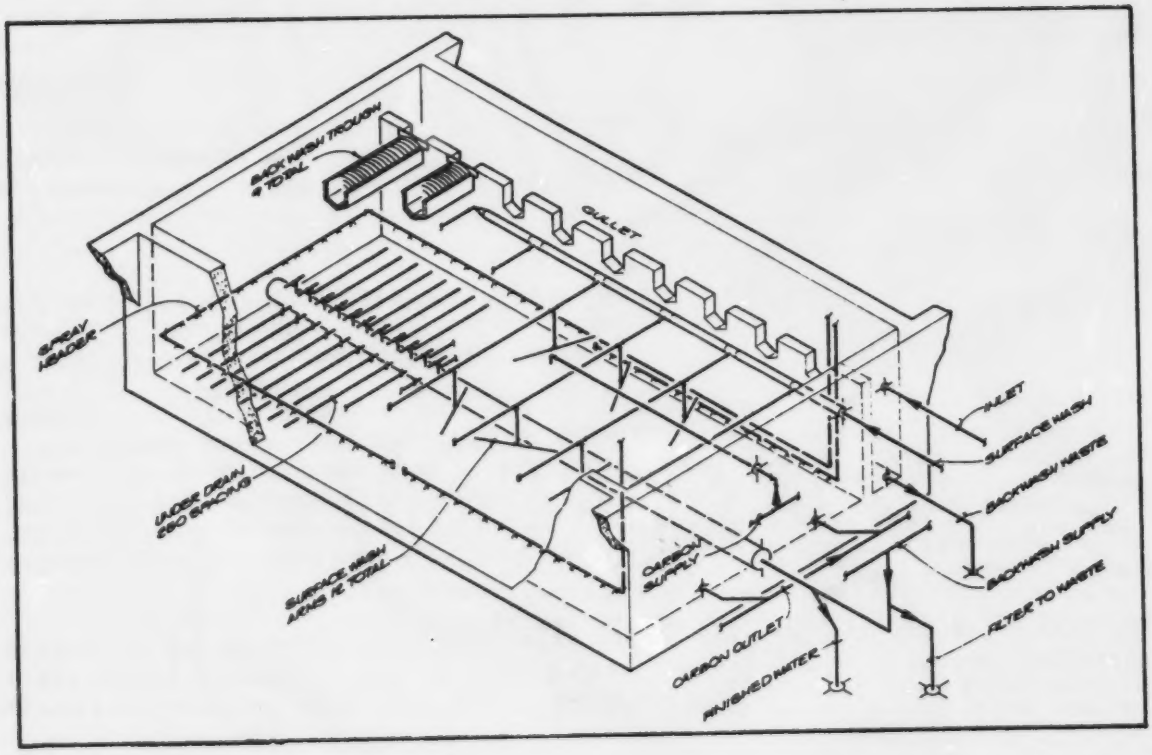


FIGURE 7

Contactor Arrangement



From the inlet channel the influent water is delivered by gravity to the contactors through gullets along the contactor sides and distributed to the top of the carbon beds. The water flows through the carbon and exits the contactors through a header/lateral underdrain system to the clearwell space beneath the contactors.

Backwash System

The backwash system for the GAC contactors draws its water from the clearwell. Two vertical turbine pumps, capacity 3170 m^3/hr (14000 USGPM) each, were installed in the existing pumproom.

These pumps (one standby) deliver backwash water through a 750 mm (30") steel line to each contactor. The precast troughs are fitted with stainless steel screens to prevent inadvertent loss of carbon. The backwash water flows through the troughs into the gullets from which it discharges to the drain channel. Rotary surface wash arms are supplied from the same pump that serves the filters.

The backwash system for the GAC contactors is activated manually with provisions for complete automation later. Pressure drop across the beds and turbidity levels of the effluent are recorded and indicated at the control room panels. Time intervals between backwashes for each contactor are also recorded.

The backwash system for the existing filters in the treatment plant is gravity supply from head tanks located in the top floor of the building. The GAC backwash pumps and piping system are designed to serve the filters, thus making the head tank storage available for other uses.

Backwash design flow is 54 $m^3/hr/m^2$ (22 USGPM/ft^2) maximum.

Chlorination

The existing chlorination system at the plant, which until this time had served only as a back-up to the lake intake chlorination system, was upgraded to provide full-time post chlorination. A new dual system with automatic switch-over was installed together with a flow-paced chlorinator and residual analyser.

Carbon Testing

The pilot plant used for the initial study was modified to serve as a carbon test unit to evaluate the effectiveness of carbon from different suppliers. The results from this test were used to finalize the carbon purchase specifications.

Three columns were run in parallel with a different carbon in each. Two columns were 1.5 m (5 ft) long and one was 3 m (10 ft) long with a mid-bed sample point. The columns were run in parallel for 13 weeks in the summer of 1984. To arrive at the specification for carbon supply, removal efficiencies for taste and odour, TOC and THMs were measured and related to iodine number. In addition, visual observations of attrition during backwash were compared with hardness number of the carbons.

The carbon testing program also showed relatively early breakthrough of organic nitrogen compounds which had not been seen earlier. This may result in a detectable nitrogen trichloride-type odour in the post-chlorinated water in late

summer. Bench-scale testing has established that this odour can be largely eliminated by aeration. A system to add aeration to the clearwell has been designed and will be constructed should full scale experience confirm the test work.

Carbon Regeneration

In a facility of this size, onsite regeneration facilities are an economic necessity. Approximately 662,000 kg (1.5 million pounds) of carbon are in service. The expected exhaustion frequency is once per year.

The cost of carbon is $1.67/kg ($0.76/lb) delivered and placed, while the cost of regenerating carbon is approximately $0.28/kg ($0.129/lb), including losses. Onsite regeneration, therefore, enjoys an estimated operating cost advantage of $945,000 per year over a fill-and-dump operation. This is sufficient to pay out the $3 million for regeneration facilities capital cost in 3.2 years.

There are some companies in the eastern U.S. that will regenerate carbon on a contract basis. Fluctuations in freight rates, currency exchange rates, and relative fuel costs make an economic comparison difficult, but, assuming that operating efficiencies are equal, the freight cost, profit, and extra fuel costs alone amount to at least $520,000 per year over onsite regeneration.

Activated carbon in this application is regenerated thermally. The carbon is first dried and then heated to approximately 870°C in an atmosphere of burner off-gas and steam with oxygen controlled at 0.2%. The adsorbed organics are pyrolyzed at that temperature and the heat and steam combine to reactivate the adsorption sites. Oxygen is controlled to limit combustion of the carbon.

The pyrolyzed organics are then incinerated in an atmosphere of excess oxygen. The regeneration is quenched in water and sent to storage.

Regeneration Equipment

The furnace system selected is a two-stage, gas-fired, fluid bed system supplied by Wesvaco Inc. and shown schematically on Figure 8. This design is relatively new, the first commercial unit having been put in service in 1978. It is cheaper to operate, easier to control, and more effective at regeneration than the older, multiple-hearth process.

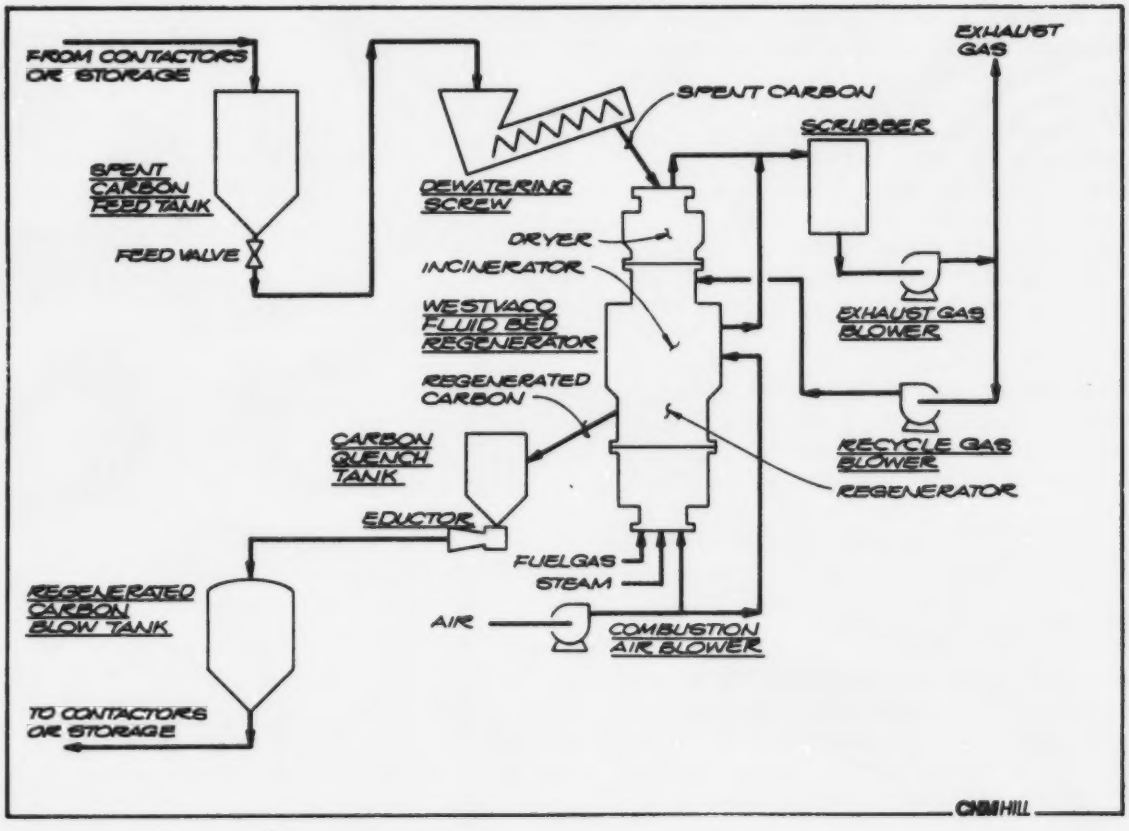
The furnace capacity of 6350 kg/day (14000 lb/day) was selected to allow for future water plant expansion plus an allowance to account for the possibility of more frequent than anticipated regeneration. Initially, the furnace will be capable of regenerating the entire inventory of carbon in three and a half months.

Carbon is fed in a slurry from the feed tank to a dewatering screw conveyor which transfers the carbon into the drying section and serves as a water seal into the furnace. The drying section is a fluidized bed in which hot exhaust gases suspend and dry the carbon at approximately 150°C. The dry spent carbon then overflows through a rotary valve into the regeneration section. The regeneration section is also a fluidized bed in which hot gas from the burner and steam suspend and regenerate the carbon at approximately 870°C. The oxygen content of the burner off-gas is carefully controlled to prevent combustion of the carbon. Regenerated carbon overflows into a water quench tank via a

submerged connection. During regeneration the adsorbed organics are driven off and enter the incineration section. Excess air is added to complete combustion and to maintain 3% excess oxygen. Most of the exhaust gases from the incinerator section are sent through a two-stage, wet scrubber to remove carbon fines and reduce moisture content. A portion of the cooled exhaust gas is blended with the remainder of the incinerator exhaust gas and used to heat the drying section.

FIGURE 8

Regeneration System Schematic



The entire process operates with a high degree of automatic control. The control system hardware for this furnace is a Texas Instruments PM 550 programmable logic controller.

Carbon Handling

In addition to the furnace, the facilities include carbon storage tanks, a carbon transfer system, and ancillary services.

The highest operating cost of regeneration is lost carbon and one of the major causes of lost carbon is attrition during transport. The preferred operating mode is, therefore, one that involves minimum handling. In this mode one contactor is emptied to storage and a second one is transferred directly to the furnace and directly back to the first contactor. Each contractor is

regenerated in turn until the first lot of carbon is transferred from storage, through the furnace, and back into service. The only disadvantage to this mode is that at least two contactors are out of service for the full time of slightly more than three months.

If regeneration is required during summer when all contactors must remain in service, the second operating mode is used. A spare charge of carbon is held in storage. Carbon from contactor is sent to storage and the fresh charge immediately replaces it. The spent charge is then regenerated and held in storage and the process is repeated for all remaining contactors. In this method one contactor is out of service for a day or so every 18 days. The double handling, however, does increase carbon losses.

Four open-top tanks provide storage for the volume of carbon contained in two contactors.

One spare charge of carbon is held in storage for use in replacing losses and for use in the second operating mode.

Two methods of carbon transfer are used -- blow case and eductor. In blowcase transfer the carbon is slurried into a pressure vessel and accumulates there while the transport water overflows. After the tank is full, valves are swung over and the dense carbon slurry is forced out the bottom by water pressure applied at the top. This is the preferred transfer method as it produces minimum shear velocities and related carbon attrition.

In eductor transport a standard water service eductor is close-coupled to the bottom of a cone-bottom tank. High pressure water applied to the eductor creates the necessary suction at the bottom of the tank to keep the carbon moving and supplies the slurry transport water.

CONSTRUCTION

The preliminary design report detailing the results of studies, bench-scale tests, and pilot plant runs was issued in December 1980. The Buffalo Pound Water Administration Board accepted the report and established a goal of implementing control measures to improve the taste and odour of finished water for the treatment plant at the earliest possible date.

After evaluating and discarding several interim measures to control taste and odour by the summer of 1981, a decision was made to start on the final design of the facilities and plan to have the GAC contactors operational by July 1982. This project schedule, 18 months from start of final design to project completion, is approximately 12 months shorter than what is normally allowed for a project such as this. A fast-track schedule was developed to achieve this. According to this schedule, the consultant would be the construction manager for the overall project and separate contracts would be awarded in series for structural, mechanical, and electrical work to allow design and construction to proceed simultaneously. In addition, prepurchase of long-delivery items, such as electrical switchgear and screw pumps, was planned.

Approval to proceed on the basis of this fast-track schedule was given in January 1981. Design of the facilities was well advanced and tender documents for the structures contract had been issued when, in June 1981, the project was shelved due to funding uncertainty.

The project was reactivated in early 1984 to proceed on the same fast-track, construction management concept as before. Some modifications to the 1981 design were carried out, and a detailed critical path schedule for all work was developed, calling for the GAC facilities to be operational by May 1985.

Table 1 lists the construction contracts placed and owner-supplied items purchased for the project. It was realized from the outset that coordinating the various contractors and establishing approximate interfaces between their work scopes would be an important aspect of managing the project. In addition, since the project entailed an expansion to an operating plant, the requirement to involve plant administration personnel at all stages was understood. As well as regular site meetings with individual contractors, biweekly coordination meetings, chaired by the construction manager and attended by all contractors and plant personnel, were held to discuss items such as interface difficulties, schedule problems, connections to existing plant, site safety, etc. Plant personnel and resident engineers also attended ongoing design review meetings.

TABLE 1

Listing of Contracts

TITLE	Awarded	Amount ($ 1000)	Contractor/Supplier
Construction			
Electrical Relocation	March 84	58	State Contractors
Building Relocation	April 84	16	Cardinal Construction
Siteworks & Structures	April 84	2139	Tobac Construction
Mechanical	June 84	1417	Comstock International
Electrical/I&C	Sept. 84	573	Energesis Control
Regeneration Furnace	Oct. 84	1237	Westvaco
Carbon Regen. Facilities	Feb. 85	1708	PCL - Maxam
Owner-Supplied Items			
5 kv Switchgear and Motor Control	March 84	49	Wesco
Cables	March 84	20	Gescon
Screw Pumps	April 84	286	Gray Engineering
Vertical Turbine Pumps	June 84	82	Wilron Equipment
Process Valves	July 84	199	Various
Air Compressor/Dryer	July 84	14	Mandem
Chlorinators	Oct. 84	34	Wallace & Tiernan
Carbon (inc. Loading)	Nov. 84	1321	CECA/Calgon

An important facet of this contraction management concept is the expeditious approval and placement of construction contracts and purchase orders. The City of Regina, which administered the project on behalf of the Buffalo Pound Water Administration Board, was cognizant of this. Tenders were checked and a recommedation for award prepared by the consultant. City of Regina staff members were then responsible for expediting contract award by their council.

The shortened time intervals between tender closings and contract awards are a tribute to the diligence displayed by City of Regina Engineering and Purchasing personnel. Without it, the overall project schedule would not have been met.

The critical path schedule prepared at the beginning of the project was updated biweekly on the basis of the individual schedules prepared by each contractor. Each major contract had key dates for partial and full completion built into it. Progress was monitored on a daily basis and remedial measures enforced where a contractor fell behind schedule, particularly where this slippage had an impact on consequent work by other contractors.

Once delivered to site, owner-purchased items were handed over to the relevant contractor whose responsibility it was to install and commission the equipment. Constant monitoring, shop inspection, and expediting were necessary to ensure delivery dates were met.

Construction and commissioning of the GAC facilities were completed on schedule in May 1985. The expansion was officially opened on June 11, 1985.

Total construction costs for the GAC facilities, including the regenerating plant, amounted to $9.8 million or $306,000 per MIGD.

ACKNOWLEDGEMENTS

The authors would like to acknowledge the cooperation and assistance of City of Regina engineering personnel and Buffalo Pound Water Treatment Plant administration staff in preparing this paper.

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MUNICIPAL AND INDUSTRIAL SEWAGE TREATMENT JOINT VENTURE

by

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BACKGROUND

In the late 1960s the City of Lethbridge faced a serious dilemma. Effluents discharged from the municipal sewage treatment plant to the Oldman River consistently violated environmental standards. The City had the option to enact and enforce strict sewage by-laws or face a land title freeze threatened by the Provincial Government.

At that time Lethbridge had developed only on the east side of the Oldman River and the City was in the midst of a major investment and commitment to expand to the west side. A land title freeze would stop westward expansion and consequently this option was not acceptable. Likewise, enforcement of strict pollution control standards would jeopardize the economic viability of 9 major food processing industries which represented a significant source of tax revenues and jobs for the City thus making this option equally unacceptable.

Under these tense conditions the City called together the major food producing industries to begin plotting an effective pollution control strategy. The agenda for that initial meeting simply outlined the problems and that the City would require their co-operation. The City indicated that the simple solution of building larger and better municipal treatment facilities would not be acceptable to the public and that some sort of pretreatment must be considered. The industries indicated a willingness to co-operate but stressed that they would need time and financial assistance to implement improvements.

MUNICIPAL PLANT EXPANDED

The initial plan of action arising out of these early meetings is summarized below:

1. The City would expand and upgrade its sewage treatment facilities from primary to secondary treatment.

2. The City enacted a comprehensive Sewage Service Charge By-Law containing the following features:

    i) a six year staged reduction of effluent limits

ii) a three part sewage treatment service charge based on discharged amounts of:
   - effluent volume
   - weight of BOD
   - weight of suspended solids

iii) a surcharge on overstrength sewage with provisions for partial refunds conditional on construction of industrial pollution control facilities and good performance.

3. Each designated industry was required to install and maintain at its own expense an automatic sewage sampler and flow totalizer. Samples were to be taken proportional to flow and refrigerated until collected each morning, Monday through Friday, by City personnel. Weekend samples were to be composted into the Monday sample. All collected samples were to be analysed for suspended solids. Once per quarter, five consecutive samples representing a full week of production was to be selected at random and analysed for BOD, SS and grease. All quarterly service charges and surcharges would be based on the total effluent flow recorded and on the results of the five analysed samples.

4. The City joined with industry to form an Industrial Sewage Committee to study and plan for further improvements.

Since at this point it appeared that all problems were soon to be resolved, the City convinced the Province to lift the land title freeze.

MUNICIPAL PLANT FAILS

The secondary treatment plant was completed in 1972 but unfortunately it failed to perform up to expectations. Since Lethbridge had no experience with activated sludge plants, the well known Dr. Hatfield was requested to direct the operation of the plant until stable operating conditions could be maintained. After some weeks Dr. Hatfield concluded that the plant would never work until more progress was made in reducing the strength of the influent to be treated and suggested chlorination of return activated sludge as a possible interim solution. Suitable chlorinators were immediately purchased and installed. After considerable experimentation a continuous dose of up to 30 mg/l was found to stablize the plant to the extent that suspended solids in the final effluent was usually less than 100 mg/l.

In 1975 a typical 24 hour composite sample of Lethbridge raw influent had the following characteristics:

parameter	units	average	low	high
Flow	m^3/d	24,600	16,000	37,000
BOD	mg/l	389	290	1800
Suspended Solids	mg/l	372	280	1100
Grease	mg/l	290	160	900

Industry was responsible for about 1/4 of the volume, 1/2 of the BOD and suspended solids, and almost all of the grease. Because of the very large industrial component, a very pronounced correlation existed between the raw flow and influent strength. As flow increased so did the concentration of BOD. It

was not uncommon for the Lethbridge municipal plant to receive in one a day a BOD load equivalent to that of a city with a population of 250,000. At that time the population of the city was only 46,700.

It also became clear that most of the nine industries would not be able to reduce their effluent strength below the by-law limits scheduled for 1979 by employing only primary treatment methods such as screening, settling and skimming. The scheduled by-law limits were 300 mg/l for BOD and suspended solids. Grease was limited to 100 mg/l.

CITY AND INDUSTRY STUDY PROBLEM

Prompted by a poorly performing municipal plant and by treatment difficulties encountered by industry, two studies were jointly commissioned. The objective of the first study was simply to define the magnitude of the problem. The objective of the second study was twofold. The first was to determine the type of treatment required at each industry and the second objective was to determine whether individually operated treatment plants or a joint facility would be most economical. A number of processes were piloted and eventually it was concluded that a jointly operated facility would be the most practical and economical of the options available. Specifically, it was proposed to collect industrial sewage using a separate collection system and to treat it in a conventional activated sludge plant designed to aerate primary clarified effluent for 24 hours. Secondary clarified effluent from the industrial pretreatment plant was considered equivalent to domestic sewage and was to be treated in existing municipal facilities.

CITY PREPARES FOR NEW NEGOTIATIONS

The next series of meetings between industry and the City were convened to establish a basis for cost sharting of the proposed facilities. A number of deficiencies had also become apparent in the new Sewage By-Law and these were to be corrected if possible. For example, some industries found it to their advantage to dilute their effluent with clear water when ever they expected to exceed effluent strength limitations. This tactic, although it made economic sense from their point of view compounded problems at the treatment plant. Not only was the plant subjected to the same BOD and SS load as before but now less time was available for treatment because of the higher flows.

In preparation for the upcoming negotiations the City formulated the following objectives to assist in the evaluation of proposals for allocating capital and operating costs to each of the participating industries:

1. A fixed percentage of the total industrial pretreatment capacity should be reserved for each participating industry's exclusive use.

2. Capital and operating costs should be allocated to each industry in proportion to the fraction of plant capacity reserved for that industry.

3. The fraction of plant capacity reserved for an industry should be related to the effluent load limits assigned to that industry as follows:

$$X_i = 0.4*V_i + 0.3*B_i + 0.3*S_i$$

where X_i = the fraction of total plant capacity reserved for the i'th participating industry.

V_i = the fraction of total plant volumetric capacity (m^3/d) reserved for the i'th participating industry.

B_i = the fraction of total plant BOD removal capacity (kg/d) reserved for the i'th participating industry.

S_i = the fraction of total plant suspended solids removal capacity (kg/d) reserved for the i'th participating industry.

(note: the arbitrary constants of 0.4, 0.3 and 0.3 which reflect the approximate relative cost of treating the respective sewage components of volume, BOD and SS were previously incorporated in the Lethbridge Sewage By-Law and the same constants would provide continuity in agreements with industry.)

4. The allocated effluent load limits assigned to each industry should protect the pretreatment plant from prolonged overloading through a provision of surcharges.

5. Surcharges levied for load limit violations should progressively increase with the magnitude of the violation, and the method of calculation should protect industries from surcharges for an occasional spill or abnormal condition.

6. The surcharge calculation method should properly account for the effect of effluent sampling and measurement errors.

7. The method for calculating effluent load limits should recognize that sewage treatment plant efficiency is maximized when sewage loads are constant and thus incentives should be provided to encourage minimum variation in industrial effluents.

8. The method used for allocating effluent limits to each participating industry should recognize that blending several industrial effluents will reduce the relative sewage load variation and that the resultant benefit may be returned to industry in the form of increased limits.

NEGOTIATIONS BEGIN

Early during the negotiations the City offered to pay 1/2 of the capital cost of the proposed pretreatment plant and collection system if industry assumed all operating costs exclusive of some general services and overheads. Eventually this proposal was accepted but industry capped their contribution to $2 million. The City then insisted on limiting the size of the plant so that the City's share would not be much more than $3 million.

Since the proposed pretreatment plant would be designed to handle a certain volumetric flow as well as limited mass flows of BOD and SS, it was readily agreed that each industry would receive effluent discharge limits based on the preceding three load parameters. Eventually, it was also agreed that sharing of capital and operating costs between the industries would be based on the

effluent limits assigned to each. Some of the more seasonal industries argued that capital costs could be shared on that basis but that operating costs should be proportioned to use made by each industry during each quarter. The City pointed out that once a plant is built to treat a certain load then operating costs are not all that sensitive to load variations.

The need to levy surcharges for limit violations was reluctantly accepted by industry as a realistic means of protecting their purchased share of capacity in the pretreatment plant. The objectionable aspect of a surcharge was considerably reduced when the City offered to refund with out time limit all surcharges if industry installed on their premises approved pollution control equipment. The amount refunded would only be limited by the value of the equipment installed and the total surcharge accumulated by a particular industry. The refund to industries participating in the pretreatment plant would not be conditional on improved performance as specified in the Sewage By-Law.

Agreement on a basis for determining how large the allocation of pretreatment plant capacity should be for each industry was much more difficult to obtain than agreement in other areas. During the negotiations each industry probably attempted to balance the possible need of future capacity against the current cost of obtaining the required effluent limits. The greater their perceived need the greater the cost. Undoubtedly the surcharge provision complicated industries assessment of their capacity requirements. Future surcharges could be reduced or avoided by purchasing more of the available capacity now. The limits that were finally established for each industry were based more on historical information then on projected requirement.

AGREEMENT REACHED

The final form of the agreement provided seven of the original nine industries with a permit to discharge effluents up to limits that were established individually for each industry. Palliser Distillers Ltd. opted out of the joint pretreatment plant and chose to treat its effluent in a small settling pond and partially aerated lagoon. Swift Ltd., a meat packing plant, chose to pioneer the "electro z" process with assisting federal grants.

Most of the previously defined objectives were incorporated into the agreements including a progressive surcharge. The surcharge is proportional to the product of an industry's normal quarterly service charge and a statistical parameter that estimates the fraction of time that an industry is in violation of any of its three effluent discharge limits. Effectively the surcharge does not come into play until the average of an effluent load parameter plus its standard deviation exceeds its permit limit. The service charge paid by each industry represents its share of the cost of operating the industrial pretreatment plant and collection system. Cost sharing was based on ownership and not on use.

An interesting feature of the agreements is that the sum of the permit limits allocated to the industries exceeds the design capacity of the pretreatment plant by approximately 15%. This is possible because of the considerable amount of blending that takes place in the industrial collection system and because of the statistical nature of the permit limits.

CONSTRUCTION BEGINS

Once the agreements were in place an engineering firm was engaged to complete

detail designs and to provide resident engineering services during construction. A separate industrial collection system was constructed consisting of 2 lift stations and a combination of polyethylene force mains and gravity mains for a total length of approximately 3 miles.

At the main plant a new grit tank, primary clarifier, aeration tank and secondary clarifier were constructed to complete the project. The industrial pretreatment plant was completed early in 1981 and has continued to work better than anticipated.

RETROSPECT

If the city had to renegotiate with industry all over again, more emphasis would be placed on informing industry that the permit limits assigned to each industry should reflect their anticipated future needs and not their historical needs. It appeared that some industries went out of their way to show why their historical record was abnormally high and consequently that they could safely get by with lower limits. No doubt this action was motivated by a provision in the agreement to link operating and capital costs directly to the permit limits. One company in particular should have purchased a larger share of the pretreatment plant because now it has difficulties in meeting the permit limits. This company will be required to do more of its own pretreatment without a 50% capital contribution from the City as it could have been if it had purchased more of the pretreatment plant when it was available.

Perhaps one reasons for the above unfortunate situation is that the agreements are complex and too mathematical for some industrial plant managers to study and comprehend fully. This complexity may have led to some misunderstandings but, generally over the last four years the agreements hae been well received and are effective. Only minor changes since the initial signing have been made in the area of surcharges. Surcharge refunds for industrial pollution control equipment now exceed surcharges levied for limit violations.

Swift Ltd. which had originally opted out of the pretreatment plant was sold to Burns Food Ltd. and subsequently to Canada Packers Ltd. Canada Packers has arranged with the City to integrate its new packing plant acquisition with its other packing plant and York Farms Ltd. into a single entity as far as the agreements are concerned. The three plants now operate as one plant within the combined limits of the two original plants.

It now appears that the capacity of the industrial pretreatment plant is greater than anticipated. The plant on numerous occasions has successfully treated long duration loads well beyond its design capacity. This fortunate situation may provide the City and industry with an opportunity to distribute the available extra capacity more in line with industry's future requirements.

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CHEMICAL CONTROL OF SEWAGE PLANT ODOURS

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INTRODUCTION

Odours are inevitably associated with sewage treatment operations. A well run plant, under normal conditions will not generate odours. However, occasional plant upsets may lead to odour problems. In many cases, odours in the sewage are caused by industrial discharges, or anaerobic conditions developing overnight. Morning surge in sewage flow may dump these odorous compounds into the plant leading to odour emission episodes.

In such situations, chemical treatment of sewage can be used to control odours in a cost-effective manner.

CHEMICAL NATURE OF ODOUR

Odours are caused by organic and inorganic compounds present in sewage in minute concentrations, and capable of activating human olfactory tissues. Sewage odours have been attributed to the following compounds or categories of compounds:

- Hydrogen Sulphide
- Organic Sulphides
- Mercaptans
- Amines
- Indole
- Skatole
- Organic Acids
- Aldehydes
- Ketones

These compounds can be released from sewage by diffusion, turbulence and aeration. The reducing compounds such as sulphides, amines, indole and skatole are generally associated with anaerobic conditions, and are responsible for the typical sewage odour. Some of these, such as indole and skatole, may originate in the sewage. Sulphides may be formed by the reduction of sulphates and sulphur-bearing proteins in the sewers under anaerobic conditions. Mercaptans and sulphides may be discharged by industries such as refineries and tanneries, or may be generated by the action of anaerobic microorganisms.

In a large number of cases, especially on the planes of Western Canada, the key odour causing compound is hydrogen sulphide, generated because of the low sewer velocities leading to anaerobic conditions. It has a typical 'rotten egg' odour, and can be a serious nuisance even in very low concentrations. Chemical treatment methods are discussed with reference to hydrogen sulphide control but apply to other odour compounds as well.

CHEMICAL TREATMENT

One method of preventing hydrogen sulphide and other compound causing odours is to add an oxidizing chemical to the influent sewage before stripping can occur. Several chemicals can be used for influent treatment and include:

- Chlorine
- Hypochlorite
- Hydrogen Peroxide
- Oxygen

1. Chlorine - Chlorine is a strong oxidizing compound that can oxidize hydrogen sulphide. The theoretical dosage required is 8.5 kg of chlorine per kilogram of hydrogen sulphide, although the actual dosage required at a given plant may vary.

2. Hypochlorite - Hypochlorine can also be used to oxidize hydrogen sulphide. The theoretical dosage required for the oxidation of hydrogen sulphide to sulphate is 9 kg of sodium hypochlorite per kilogram of sulphides oxidized. Addition of hypochlorite requires simple equipment, but chemical costs are higher than chlorine, and the latter is preferred for large scale applications.

3. Hydrogen Peroxide - Hydrogen peroxide oxidizes hydrogen sulphide to sulphur. It is claimed that complete oxidization to sulphate does not occur, hence the theoretical dosage is approximately 1 kg of hydrogen peroxide per kilogram of sulphide oxidized.

4. Oxygen - Oxygen can be applied to sewage to prevent septic conditions, and to biologically oxidize hydrogen sulphide already generated.

   The theoretical oxygen dosage to oxidize hydrogen sulphide is 1 kg oxygen per kg of sulphides. However, the bacteria will also oxidize other organic matter in the sewage with the oxygen, and this raises the required dosage to 3 kg oxygen per kilogram of sulphides.

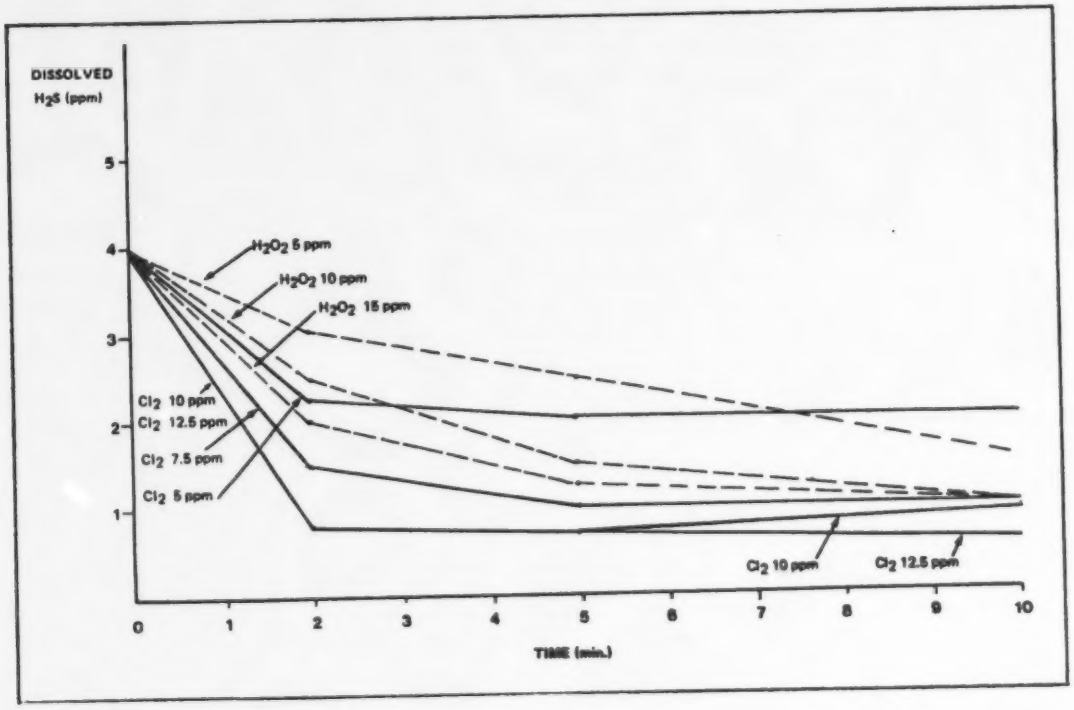
   The rate of oxidation of hydrogen sulphide with oxygen is typically 10 to 15 mg/L hr. It has been used to control hydrogen sulphide generation in forcemains, where normal surface aeration does not occur as in a gravity sewer.

   Air can also be used as a source of oxygen for oxidizing sulphides and preventing sulphide generation. Although it is less expensive, a disadvantage is that the inert gases in the air strip off odour compounds before oxidation is complete.

EFFECTIVENESS OF CHLORINE AND HYDROGEN PEROXIDE IN OXIDIZING HYDROGEN SULPHIDE

Two chemicals, hydrogen peroxide and chlorine are used most commonly to reduce odour at sewage treatment plants. As shown in Figure 1, chlorine was found to be substantially more cost-effective in the case under study. Pretreatment of sewage with chlorine was generally effective in reducing the odour levels from the grit building exhaust by up to 50 percent or more. It is of interest to note that residual odours persisted and were not affected by chemical treatment.

FIGURE 1



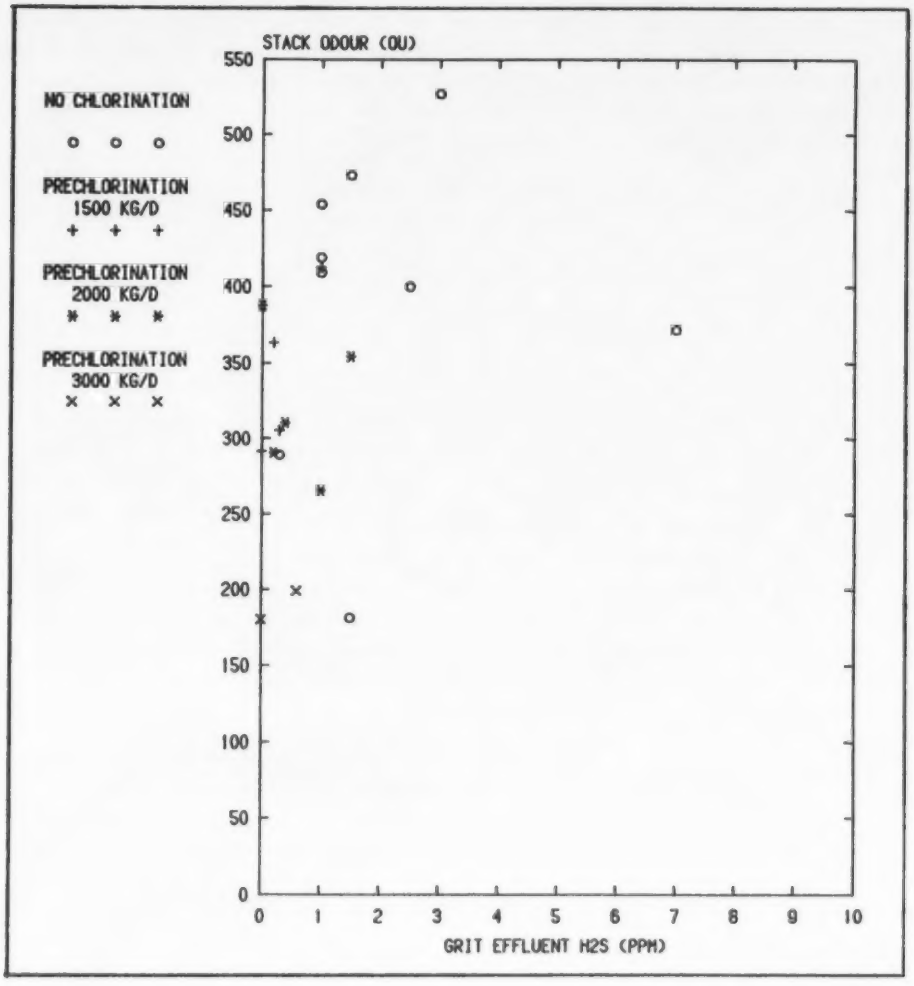
CONCLUSION

Use of chemicals such as chlorine and hydrogen peroxide is a cost effective method of controlling odour episodes at sewage treatment facilities.

These episodes may occur as a result of plant upsets, industrial discharge or anaerobic conditions that may develop in low velocity sewers so common on the Prairies.

FIGURE 2

Odour Vs Grit Effluent Sulphide



REVERSE OSMOSIS
Operation and Membrane Replacement

by

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Before discussing the operation of the R.O. unit, I would like to define the basics for those guests who may only have a slight knowledge of the Reverse Osmosis operation. The definition of R.O. is that of a membrane process that acts as a molecular filter to remove up to 98% of all dissolved minerals, about 95% - 97% of most organics and about 98% of biological matter from water.

First let us consider natural osmosis. In Figure 1a pure water is separated from a salt solution by a semipermeable membrane through which water passes easily. Osmosis is the natural process whereby pure water flows from a dilute saline solution through the membrane into a more concentrated solution.

The water flow continues across the membrane until the pressure created by the osmosis head equals the osmotic pressure of the salt solution. This is called osmotic equalibrium, as shown in Figure 1b. By applying external pressure greater than the osmotic pressure to the salt solution, the water flow across the membrane can be reversed. By reversing the flow from the salt solution to the pure water, as shown in Figure 1c, pure water is removed from the salt solution. This is known as Reverse Osmosis.

FIGURE 1a
Osmotic Flow

FIGURE 1b
Osmotic Equalibrium

FIGURE 1c
Reverse Osmosis

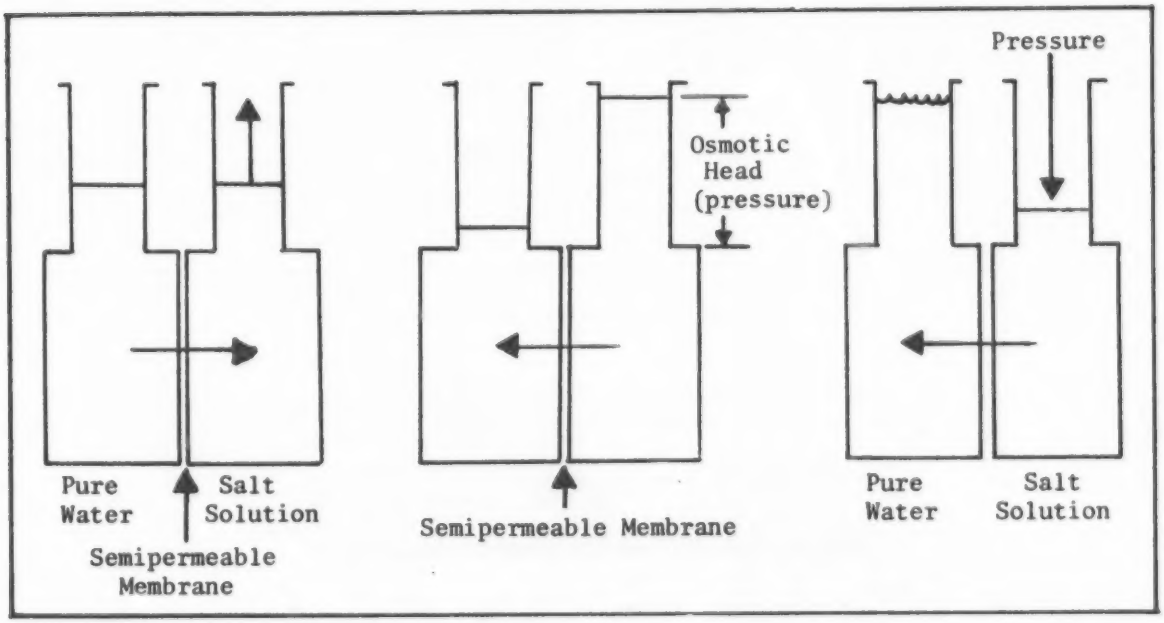


Illustration Figure 2 shows a simplified R.O. flow system. Figure 3 shows the size of the membranes and the lower illustration, Figure 4, is that of a B-9 Permeator.

FIGURE 2 - Simplified R.O. Flow System

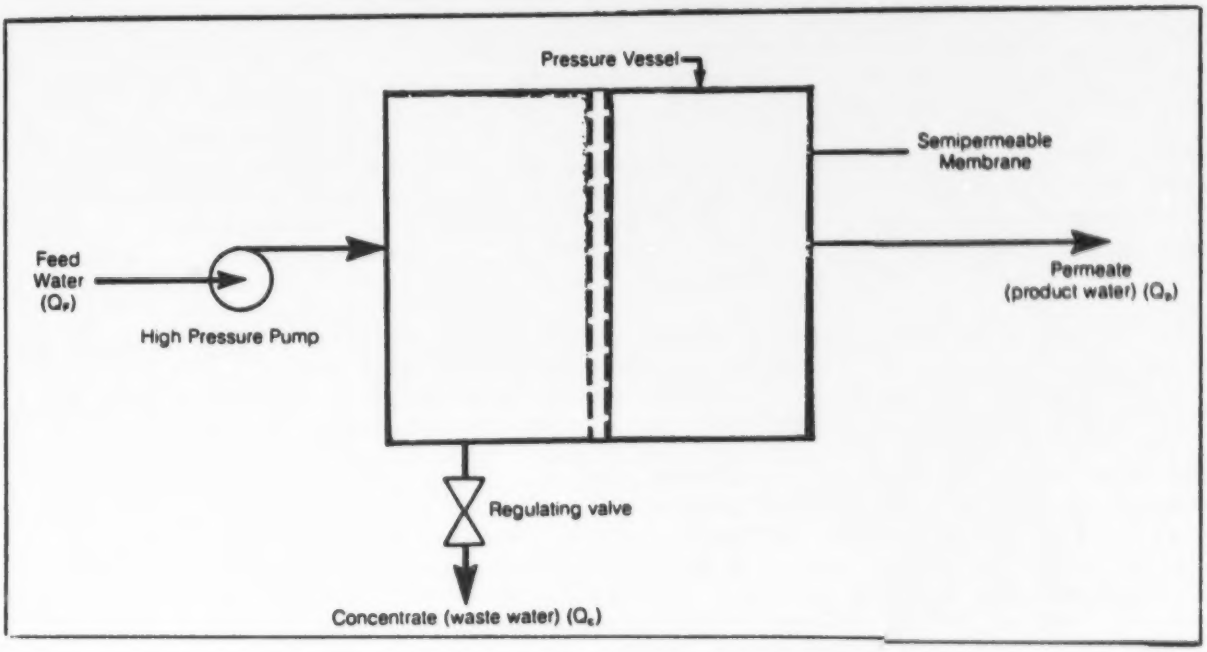


FIGURE 3 - B-9 Fibre (Asymmetric Aramid)

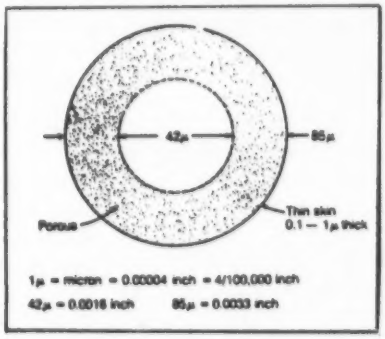
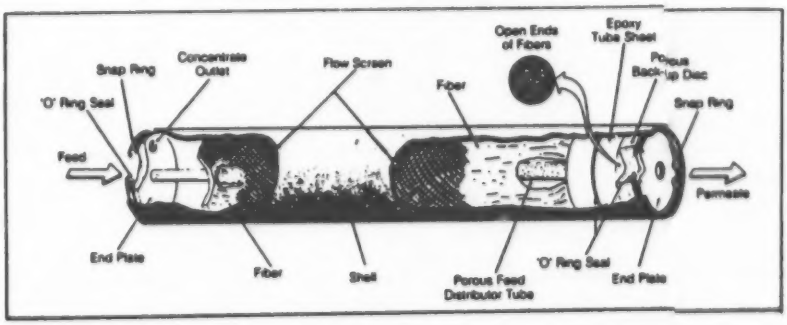
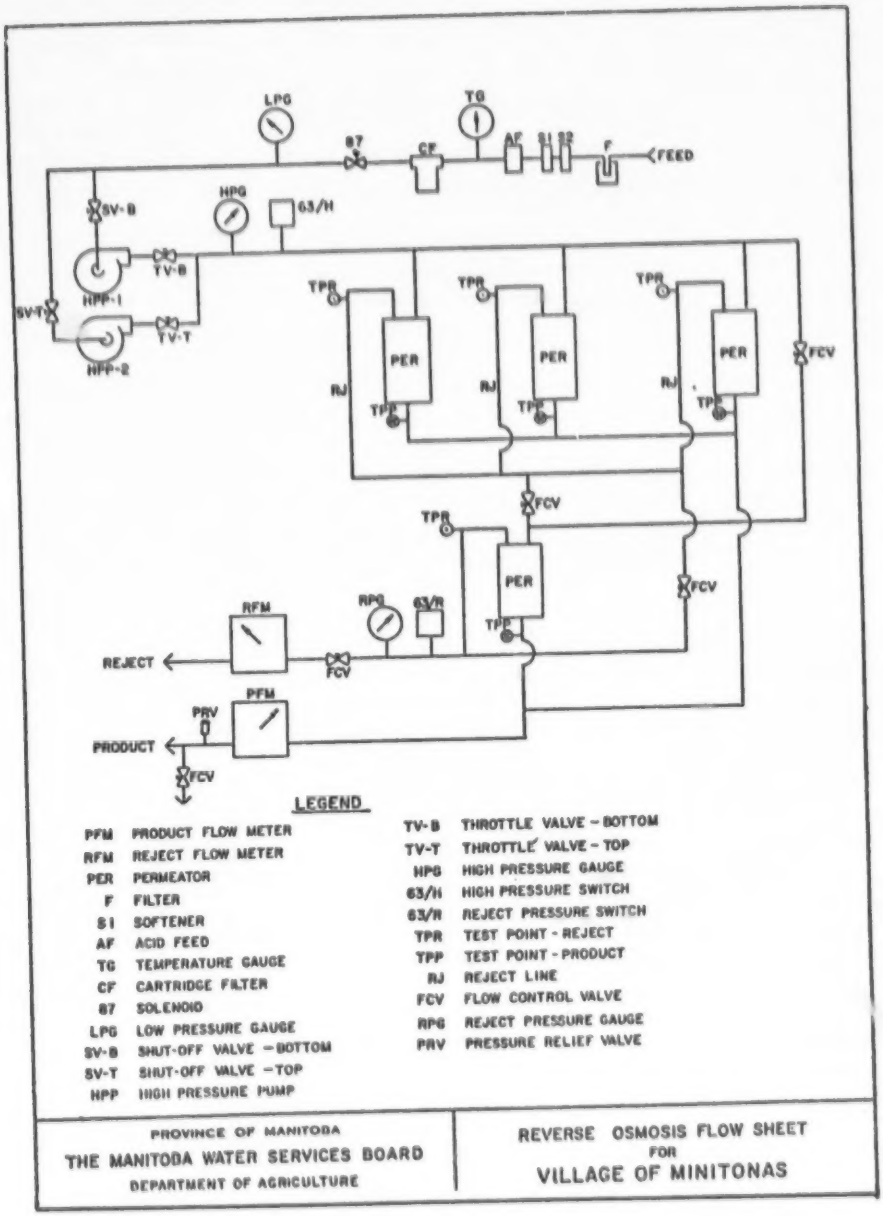


FIGURE 4 - B-9 Permeator



The Minitonas plant became operative in March 1976 and continued uninterrupted until March 1985, producing some 58 million gallons of potable water without shut down or membrane replacement due to wear or leakage.

The illustration below shows the Reverse Osmosis Flow Sheet for the Village of Minitonas.



Minitonas water has a high sodium sulphate/chloride and bicarbonate content. Hardness is about 30 ppm but due to the high sulphate we have to guard against calcium sulphate precipitation and this requires pretreatment. From 1976-1984 the pretreatment comprised of zeolite softening followed by a weak sulphuric acid solution to the feed water. The efficiency of the Minitonas operation is reflected in the fact that during the first nine years of operation, the salt rejection ranged from 98% down to 90%. Every two years the unit has been chemically cleaned and excellent records have been kept. In addition, the operator has carried out daily testing of the feed, product and reject waters.

THE MANITOBA WATER SERVICES BOARD

WQR

WATER QUALITY REPORT

Name of Plant MINITONAS Date Received 17.3.82 EPL No. 3426

Date Sampled MARCH 82 Date Completed 14.4.82 Date of Report

IDENTIFICATION:	Results Expressed in Mgs/L Raw Water	Product	Reject	
Colour	L 5.0	L 5.0	5.0	Hazen Units
Turbidity	0.3	0.2	0.5	J.T. Units
pH	8.20	6.5	7.75	
Calcium (Ca)	6.70	L 0.3	12.3	Mgs/L
Magnesium (Mg)	2.70	L 0.3	3.6	"
Sodium (Na)	1210.	94	3130	"
Potassium (K)	26	L 1.0	15	"
Iron (Fe)	0.08	L 0.02	0.116	"
Manganese (Mn)	L 0.02	L 0.02	0.02	"
Total Hardness ($CaCO_3$)	28	L 1.0	45	"
Alkalinity ($CaCO_3$)	613	64	1270	"
Bicarbonate (HCO_3)	748	78	1549	"
Carbonate (CO_3)	0	0	0	"
Chloride (Cl)	640	80	1450	"
Fluoride (F)	4.1	0.39	10.5	"
Sulphate (SO_4)	1080	42	3240	"
Elec. Conductivity	4860	502	10,700	micromhos/cm
Total Residue	3450	260	7730	Mgs/L
Filterable Residue	3450	260	7730	"
Nitrate + Nitrite (N)	0.02	L 0.01	0.02	"
Free Carbon Dioxide (CO_2)	3.0	9.0	16	"
Non Carbonate Hardness ($CaCO_3$)	0	0	0	"
Silica (SiO_2)	N/A	N/A	N/A	"

REMARKS: % SALT PASSAGE 8.2
% SALT REJECTION 91.8

REPORT TO:

1. Manitoba Water Services Board
2. Environmental Engineering
3. Public Health Regional Supervisor
4. Waterworks Superintendent

Chemist

In late 1984, the Manitoba Water Services Board requested that a chemical known as Flocon 100 be used in place of softening and acidification. Flocon 100 is a chemical that raises the solubility of calcium sulphate and calcium carbonate, thus preventing the deposition of these compounds.

In March 1985 the Manitoba Water Services Board decided that in order to meet the increased demand for water by the Minitonas community, the membranes which had been in use for 9 years, be replaced.

There are two ways of replacing the membranes:

1) To replace the complete membrane bundle contained in the shell - a simple operation done by disconnecting each membrane from the unit and placing the new complete membrane back into the unit and reconnecting the inlet and outlet sides for product and reject waters. Time required should not exceed 2-3 hours.

2) The alternative method is to purchase the membrane module without the outer shell. On a B-9 - 8" (203 mm) permeator the saving on each bundle is approximately $800.

The alternate method saves money but requires the removal of the old membrane bundles from the shell which can involve several hours of work.

Membrane bundles come very carefully packed in plastic bags and must remain packed until required. Each bundle weighs about 35 kg and contains sodium metabisulphate and 18% glycerine solution which is a sanitizing agent. Equipment required includes an End Plate Puller, Tamping Device and a Groove Filler Ring. This equipment is essential.

All fittings have to be removed from the end plates, followed by the removal of the segmented end caps. The end plates are then removed. This operation can be tricky as damage to the inner shell such as deep scratches can occur. When the end plates have been removed by means of the end plate puller, it is recommended that liberal use of a water soluble lubricant can be made on the inside of the shell. It is most important that NO hydraulic pressure be used to remove the end plates. After the end plates are removed, the screen and porous support block are removed. The inner shell must be washed and any particles removed and the shell thoroughly lubricated. To remove the bundle the water supply is connected to the permeator feed port. Pipe nipples and throttle valve are installed in brine port. Sample port must be plugged. Water is then turned on slowly to purge air from the permeator. When purging is complete, the brine throttle valve is slowly closed and the membrane bundle should eject from the shell. Water is then shut off and the bundle removed from the shell by hand. Any particles that may scratch the inner shell surface should be removed.

Installation of New Membrane Bundles

It is very important that the membrane shell be carefully cleaned and any scratches polished out. Failure to do this will prevent the O-rings from sealing. The crucial areas are the first 3 inches (76 mm) inward from the ring groove on the feed end and the first 7 inches (178 mm) inward from the ring groove on the product end. These two locations should be well lubricated and there should be no surface scratches on the shell.

The new membrane bundle should be removed from the plastic bag and new O-rings installed on the tube sheet, taking care not to roll or twist the rings. The membrane bundle (nub end first) should be carefully inserted into the product end of the shell. The bundle may be tapped into the shell using a rubber hammer and tamping device. The bundle should be tapped into the shell until the tube sheet face is about 4 inches (102 mm) beyond the O-ring groove. Care has to be taken to keep the shell surface clean and free from scratches. The porous support block is then placed against the tube sheet and the vexar screen against the block. The new O-ring should then be installed on the product end plate with care, and the new end plate pushed on by hand, ensuring at the same time that the inner surface of the shell is lubricated. New segmented ring and cap screws are then installed and this completes the product end assembly. The shell should be inverted with the product end down and the end plate assembly gently tapped with a rubber hammer to seat the membrane bundle. The end of the feed tube should be sawed to the required length so that it will fit into the end plate. New O-rings should be installed on to the feed tube and end plate and tapped carefully into place followed by the new segmented ring and screws. The completed permeator is then installed into the unit.

Before the new membrane bundles are put into service, the sanitizing agent must be removed by flushing and treatment using P.T.A. Polyvinyl-methyl-ether and Sodium Chloride.

The procedure for using these chemicals is fairly complex as all the water containing these chemicals from the unit product and waste has to go to drain.

Instructions for the post cleaning procedure are supplied with all new membrane bundles. However, the flushing and post treatment should be carried out by a competent person.

CONCLUSION

In conclusion I should mention that the time and labour cost involved in replacing the membrane bundles only as against purchasing of a complete unit (the membrane bundles within the shell complete), could prove more costly.

I would like to express my thanks to:

The Du Pont Company

Culligan Water Treatment Co., of Winnipeg

The Manitoba Water Services Board

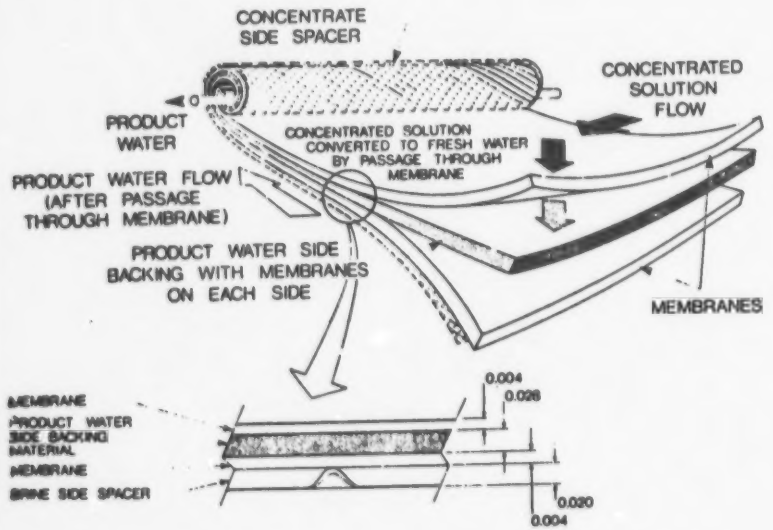
NOTE:

Drawings Courtesy of

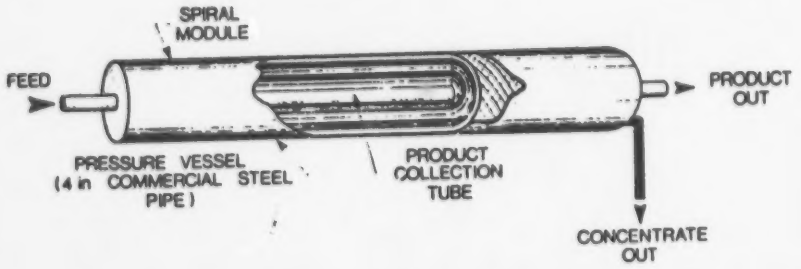
The DuPont Co.

and

Culligan Water Treatment Co.



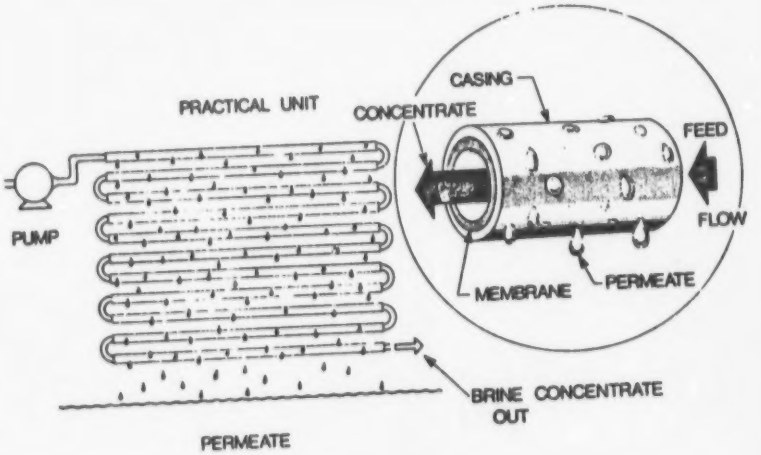
SPIRAL-WOUND MEMBRANE MODULE, PARTIALLY UNROLLED.



SCHEMATIC OF SPIRAL-WOUND MEMBRANE MODULE

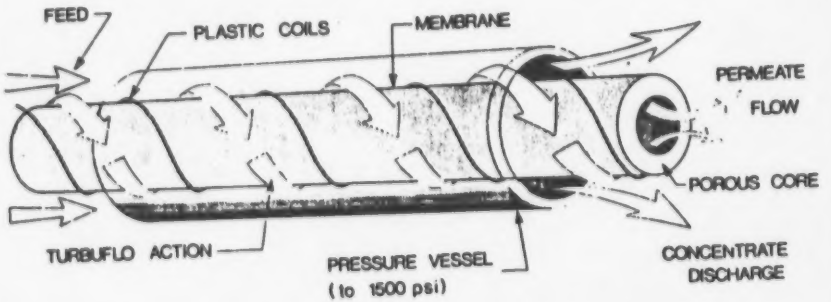
Gulf General Atomic

FIG. 3 SPIRAL-WOUND REVERSE OSMOSIS MODULE



TYPE I DESIGN WITH MEMBRANE EXTERNALLY SUPPORTED

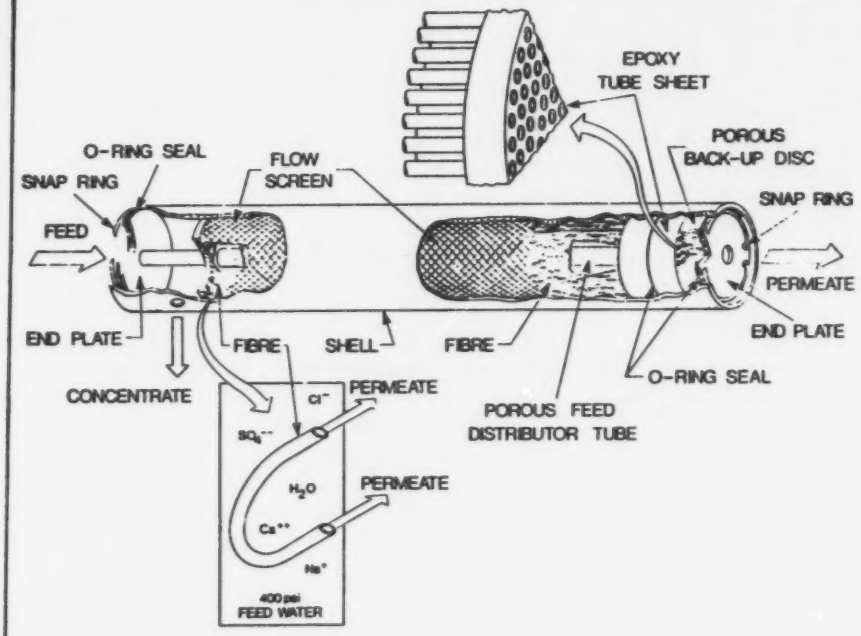
Eastman Chemical Products, Inc.



TYPE II DESIGN WITH MEMBRANE INTERNALLY SUPPORTED

Raypak, Inc.

FIG. 4 TUBULAR REVERSE OSMOSIS



COMMERCIAL PERMEATOR, CUTAWAY DRAWING
Du Pont de Nemours and Co.

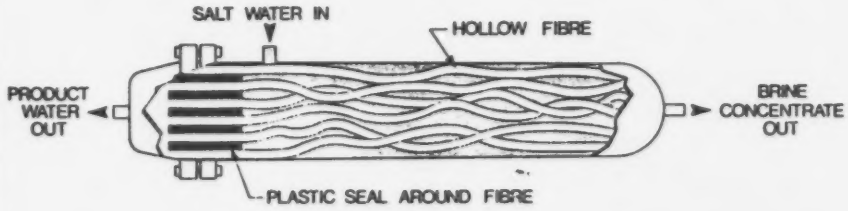


ILLUSTRATION OF HOLLOW FIBRE REVERSE OSMOSIS PROCESS.

FIG. 5 HOLLOW FIBRE REVERSE OSMOSIS MODULE

ABSTRACTS OF PAPERS
NOT INCLUDED IN THE PROCEEDINGS
OF THE
37TH ANNUAL CONVENTION
OF THE
WESTERN CANADA WATER AND SEWAGE CONFERENCE

AGING INFRASTRUCTURE - NORTHERN UTILITIES

FLIN FLON - A CASE STUDY

by

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The City of Flin Flon is a northern mining community approximately 870 km north of Winnipeg. It is currently undertaking a staged upgrading program of its municipal infrastructure. The major portion of the community was serviced with municipal services from 1947 to the early 1960's.

The existing terrain features rock outcropping, shallow overburden and significant relief across the community. Due to the terrain constraints, the cold weather environment and materials in use, the major components of the system began exhibiting rapid deterioration by the 1970's and continues today. Costs associated with maintaining the system in conjunction with the need to accomodate expansion of the community have created a situation requiring major upgrading of the existing deteriorated infrastructure.

The paper reviews an analysis of existing water supply/distribution systems and wastewater collection systems both in terms of their condition and capacity to meet existing and long term requirements. The methodology of data compilation and analysis is reviewed as well as actual construction of the initial improvements and a review of some problems experienced to date. The long term requirements of the infrastructure is discussed in terms of the following:

- Achieving an adequate design life in terms of condition and capacity.

- Thermal properties of materials to reduce operating costs of the system.

- Installation of flow and heat monitoring equipment to optimize operating dollars and reduce system maintenance costs.

BATCH REACTOR TECHNOLOGY APPLIED TO WASTEWATER TREATMENT IN MANITOBA

by

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Winnipeg MB R3B 1N7

Norbert W. Schmidtke, Ph.D., P.Eng.
President
Norbert W. Schmidtke and Associates Limited
Kitchener, Ontario

This paper describes the performance of three biological batch reactor systems in Manitoba designed to treat domestic wastewater flows. Such biological batch reactor technology has recently been revived with the advent of improved automatic process control hardware. The batch process has been developed into a cost-effective alternative for treating domestic and industrial wastewaters. The batch reactor has proven to simple to operate and has consistently produced effluent with very low B.O.D. and suspended solids values. Experiences confirm that the proper application of biological batch reactor systems is simple, inexpensive, requires a minimum of operator's skill and attention, and produces an effluent with characteristics normally associated with more complex waste treatment systems.

CASE STUDY
CORROSION OF DUCTILE IRON WATERMAINS IN THE CITY OF THOMPSON

by

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In the spring of 1983, concern over the number of watermain leaks in the Centennial West Subdivision lead to a three phase investigative program to determine both the cause of the leaks and to develop a program to minimize and/or eliminate the problem. The investigators found that this problem was a City-wide watermain corrosion problem with the degree of failures being dependent upon the age of the piping and the anode/cathode area of relationship. Sacrificial magnesium anodes were introduced as a short-term approach to protecting sections of pipe that were exposed due to watermain leaks. A more permanent innovative approach was developed using the point source impressed current cathodic protection system thus eliminating the need to excavate and make the negative rectifier connections. This new approach is experimental in nature, however, imitial tests indicate that the protection provided far exceeds original expectations.

WATER TESTING CONTEST PROCEDURES

by

Jim Warrener, P.Eng.
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Roberta York
Canada Fisheries and Oceans
Winnipeg, Manitoba

This paper will provide detailed information on the water testing procedures utilized for the First Western Canada Water Testing Contest. Described will be the thorough and correct laboratory methods and laboratory control procedures that were used to ensure the accuracy and impartiality of the results. The persons involved in the testing, and the Conference Steering Committee fully stand behind the accuracy and objectivity of the water testing procedures and results.